Final Pathway Analysis Report

Combe Fill South Landfill Superfund Site,
Operable Unit 2
Remedial Investigation/Feasibility Study

EPA Work Assignment Number 018-RICO-0256,
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Chester and Washington Townships,
Morris County, New Jersey
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Contents

Figures

Tables

Attachments

ABBREVIATIONS AND ACRONYMS

ADAF	Age-dependent adjustment factor
AT	Averaging time
BHHRA	Baseline Human Health Risk Assessment
B	Ratio of permeability coefficients for dermal water exposure
BCF	Bioconcentration factor
BW	Body weight
Ca	Constituent concentration in air
CAF	Cancer adjustment factor
CDC	Centers for Disease Control and Prevention
CLP	EPA Contract Laboratory Program
cm	Centimeter
COPCs	Constituents of potential concern
CSM	Conceptual Site Model
DA-event	Absorbed dermal dose per event
DER	Data evaluation report
DQI	Data quality indicators
ED	Exposure duration
EDD	Electronic data deliverable
EF	Exposure frequency
ELCR	Excess lifetime cancer risk
EPA	United States Environmental Protection Agency
EPC	Exposure point concentration
FA	Fraction absorbed for dermal water exposure
FLUTe	Flexible Liner Underground Technologies, LLC
GIABS	Gastrointestinal absorption factor
HDR	Henningson, Durham and Richardson Architecture and Engineering, P.C.
HI	Hazard Index
HQ	Hazard Quotient
HWSS	EPA Region 2 Hazardous Waste Support Section
IEUBK	Integrated Exposure and Uptake Biokinetic Model
INORG	Inorganic
IR	Intake rate

IRIS	EPA Integrated Risk Information System
IUR	Inhalation unit risk
kg	Kilogram
Kp	Dermal permeability constant
L	Liter
LOAEL	Lowest observable adverse effect level
m^3	cubic meter
MAF	Mutagen adjustment factor
mg/kg-day	Milligrams per kilogram per day
mg/kg	Milligrams per kilogram
mL	Milligrams per liter
MMOA	Mutagenic mode of action
NJDEP	New Jersey Department of Environmental Protection
NOAEL	No observable adverse effect level
NPL	National Priorities List
OU2	Operable Unit 2
OSWER	EPA Office of Solid Waste and Emergency Response
PAR	Pathway Analysis Report
PCB	Polychlorinated biphenyl
PEST	Pesticide
PPRTV	EPA Provisional Peer Reviewed Toxicity Values
QAPP	Quality Assurance Project Plan
QL	Quantitation Limit
RAGS	EPA Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RDCSRS	NJDEP Residential Direct Contact Soil Remediation Standards
RfD	Oral reference dose
RfC	Inhalation reference concentration
RI/FS	Remedial Investigation/Feasibility Study
RME	Reasonable maximum exposure
ROD	Record of Decision
RSL	EPA Regional Screening Level
SF	Slope factor

STSC	Superfund Health Risk Technical Support Center
SVOC	Semi-volatile organic compound
TAL/TCL	EPA target analyte list / target chemical list
TCE	Trichloroethylene
TDS	Total dissolved solids
t*	Time to reach steady state for dermal water exposure
t-event	Event duration for dermal water exposure
tau-event	Lag time per event for dermal water exposure
TIC	Tentatively identified compound
TOC	Total organic carbon
TSS	Total suspended solids
UCL	Upper confidence limit
UNT	Unnamed tributary
VOC	Volatile organic compound

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1 Introduction

This Pathway Analysis Report (PAR) has been prepared on behalf of the United States Environmental Protection Agency (EPA) by Henningson, Durham & Richardson Architecture & Engineering, P.C. in association with HDR Engineering, Inc. (HDR) to assess the nature, magnitude and probability of potential harm to public health posed by contamination in the deep groundwater aquifer as part of the Remedial Investigation/Feasibility Study (RI/FS) for the Combe Fill South Landfill Operable Unit 2 (OU2) Superfund Site in Morris County, New Jersey.

This PAR is based upon the February 2, 2010 EPA Statement of Work, the 2011 Quality Assurance Project Plan (QAPP) and Subtask 1.13 as described in the EPA-approved April 2011 RI/FS work plan. The PAR has also been performed in accordance with EPA Risk Assessment Guidance for Superfund (RAGS; EPA1989).

This PAR was developed to characterize the exposure setting and human receptor characteristics for Operable Unit Number 2 (OU2) at the Combe Fill South Landfill Superfund Site. It identifies the current and future land use exposure pathways by which populations may be exposed to contaminants identified in OU2 groundwater and associated surface water and sediments. Exposure pathways were identified based on consideration of the sources and locations of contaminants, the likely environmental fate of the contaminants, and the location and activities of the potentially exposed populations.

The PAR identifies the potential exposure points and routes of exposure for each exposure pathway, as well as parameters regarding human receptor characteristics and behavior (e.g., body weight, ingestion rate, and exposure frequency) and toxicity criteria. The PAR does not include any risk estimates; this information is included in the Baseline Human Health Risk Assessment (BHHRA). The PAR does not include any hazard quotients for ecological receptors and endpoints; this information is presented in the screening level ecological risk assessment (SLERA).

1.1 Overview of the PAR

The purpose of the PAR is to serve as a preliminary planning document to allow stakeholders to review and comment on the approach to the Constituents of Potential Concern (COPC) identification, exposure assessment and toxicity assessment before work on the BHHRA is initiated, so that appropriate changes can be made to the assumptions that will be used to estimate exposure and risk.

The PAR describes the risk characterization process and how the BHHRA will be prepared, to ensure that the proper guidance and methodologies are followed. This report contains the information necessary to understand how the risks at the site will be addressed, including the statistical treatment of the data, the methods to select the COPCs, the exposure pathways, receptors, exposure parameters, and the current toxicological values (e.g., reference dose).

1.2 PAR Contents

The PAR is organized as follows:

Section 1 Introduction: Identifies the purpose of the PAR and the areas to be addressed.

Section 2 Site Background: Describes the Site location, history and contamination.

Section 3 Sample Collection, Data Evaluation and Identification of COPCs: Describes the collection and preparation of data sets and the process by which the COPCs were identified.

Section 4 Exposure Assessment: Presents a conceptual site model (CSM) that identifies the exposure pathways and potentially exposed receptors and describes how exposure intakes will be calculated.

Section 5 Toxicity Assessment: Provides a discussion of the toxicity values and the hierarchy by which they are chosen.

Section 6 Risk Characterization: Provides a description of the carcinogenic classes and the methods by which cancer risks and noncancer hazard quotients will be calculated.

Section 7 References: Provides information on the literature cited in the PAR.

2 Site Description

This section includes a summary of information related to the location, history and contamination known to be present.

2.1 Combe Fill South Landfill Operable Unit 1

Combe Fill South Landfill Operable Unit 1 (OU1) is located at 98 Parker Road, Chester Township, Morris County, NJ (Figure 1-1). It is an inactive municipal landfill that consists of three separate fill areas which were capped and closed in the mid-1990s (New Jersey Department of Environmental Protection [NJDEP] 2011a). The extent of the landfill property is approximately 115 acres and lies within Washington and Chester Townships.

Beginning in the 1940s, Combe Fill South was operated as a municipal refuse and solid waste landfill and for the disposal of household and industrial wastes, animal carcasses, sewage sludge, septic tank wastes, chemicals and waste oils. Landfill operations ceased in 1981, after which the Combe Fill Corporation filed for bankruptcy and was liquidated. According to records summarized in the 1986 Remedial Investigation (RI) report, conducted by Lawler, Matusky & Skelly Engineers (LMS 1986), about five million cubic yards of waste material are buried in the landfill.

The landfill was listed on the Superfund National Priorities List (NPL) on September 1, 1983. EPA filed a Record of Decision (ROD) in 1986 and selected a remedy that included: (1) providing an alternate water supply system for affected residents; (2) covering the landfill with clay or a synthetic material to prevent surface water and rainwater from coming into contact with the buried wastes in accordance with Resource

Conservation and Recovery Act (RCRA) requirements; (3) installing a system to collect the landfill gases; (4) pumping the shallow groundwater and leachate and treating it prior to discharge into East Trout Brook; (5) installing controls to accommodate stormwater runoff and seasonal increases in precipitation; and (6) performing an additional study to determine if the deep aquifer needs treatment (EPA 2013a).

The landfill currently includes a roughly 65-acre multi-layered terraced cap, passive landfill gas venting system, shallow groundwater recovery and treatment systems, security fencing, surface water runoff controls, and a perimeter access road.

2.2 Deep Bedrock Aquifer Operable Unit 2

Groundwater contamination was identified in the deep aquifer, designated as OU2. The deep aquifer is the major source of potable water for residential properties in the vicinity of the landfill. Private residential supply wells northeast of OU1 have been impacted with chemicals, e.g. volatile organic compounds (VOCs) - 1,4-dioxane in particular - that have migrated from the landfill. Approximately 325 homes along Schoolhouse Lane, Parker Road and parts of Old Farmers Road were defined as being in need of an alternate water supply. A municipal water supply was recently constructed to serve properties impacted by groundwater contamination (EPA 2015b).

EPA assumed the lead for a study of the deep aquifer in July 2009. The OU2 RI has been completed to characterize the nature and extent of this contamination and evaluate potential exposure and the potential human health and ecological risks.

At the outset of the OU2 RI, the OU2 study area, which extends well beyond the boundaries of the landfill property, was generally bounded to the north by residential parcels on both sides of Schoolhouse Lane, to the east by Parker Road, and to the south and west by individual residential and agricultural (horse farm) lots adjacent to the landfill (Figure 2-1), covering approximately 444 acres. These boundaries were adjusted as necessary as the OU2 RI work progressed. The OU2 study area was extended to the north to the confluence of a Lamington River Unnamed Tributary (UNT) and the Lamington River (known locally as the Black River), and to the south to a property adjoining a Trout Brook UNT (Trout Brook was historically referred to as West Trout Brook) on the south side of Parker Road. The other boundaries remain unchanged.

The geology and hydrogeology of the OU2 study area are described in the RI report; pertinent information from the RI/FS Work Plan was considered in developing the PAR.

2.3 Site Contamination

The main source of contamination is the waste buried in the landfill; an additional source is the waste within the portion of the former North Waste Cell that was unable to be excavated and remains beneath the perimeter road.

The landfill was constructed by clearing overburden and placing waste directly on or near the bedrock surface. The landfill has been capped and a shallow groundwater collection and treatment system is operational; the collection system is mainly limited to recovering from the overburden, as only one of the recovery wells is screened in bedrock. Shallow bedrock fractures serve as conduits through which contaminated leachate is transported into the deeper fracture network in the immediate vicinity of the landfill.

The nearby surface water bodies were studied to determine if contaminated groundwater is impacting surface waters. Historically, landfill leachate, as well as groundwater and surface water runoff from the southwestern portion of the landfill constituted the headwaters of East Trout Brook and Trout Brook (LMS 1986). To evaluate the groundwater/surface water interaction, synoptic depth to groundwater measurement events were conducted in May 2012 and July 2015, water levels were measured throughout the field investigation from 2011 to 2015 and data loggers were installed in each piezometer/stream gauge pair to monitor surface water levels for a period of three months from August to November 2011. It was determined that shallow groundwater discharges to surface water along Trout Brook to the south, Tanners Brook UNT to the west, and the Lamington River UNT along Schoolhouse Lane to the northeast, making these gaining streams. The upper portion of East Trout Brook to the southeast of the landfill may at times be a losing stream, while the lower portion is often a gaining stream.

East Trout Brook receives the groundwater treatment plant effluent. In the absence of heavy precipitation and resulting overland flow, the effluent is the main source of water for the stream.

3 Sample Collection, Data Refinements and Identification of COPCs

HDR collected and managed data as outlined in the QAPP (HDR 2011a). Analytical data from HDR's 2011 through 2015 sampling events were analyzed by the EPA Contract Laboratory Program (CLP) or EPA Division of Environmental Sciences and Assessment (DESA) laboratory. CLP data underwent Level 3 validation, with a subset of CLP data receiving Level 2B validation (EPA Region II 2014a). DESA performed validation in accordance with EPA Region 2 standard operating procedure (SOP) # G26 (EPA Region II 2014b). Validated electronic data deliverables (EDDs) were provided to HDR. HDR submitted the EDDs to EPA Region 2 Superfund EDD Database Section personnel.

HDR reviewed and compiled the data in a Data Evaluation Report (DER, Appendix B of the RI), to determine whether the data met the data quality indicators (DQIs) of the QAPP (i.e., representativeness, completeness, comparability, precision and accuracy), identify data gaps and determine the usability of the data for the BHHRA.

Data refinements were made to standardize the data to better support the exposure, toxicity and risk assessments. COPCs were identified based on comparison of detected media-specific concentrations to screening levels and other factors in accordance with EPA guidance (EPA 1989).

3.1 Groundwater

HDR conducted groundwater sampling from 2011 through 2015. Two samples were collected from each of the ports of the 13 multi-port wells. The multi-port wells are depth-discrete Water FLUTe™ wells provided by Flexible Liner Underground Technologies

(FLUTe™). The multi-port wells are CF201D, CF204D, CF206D, CF207D, CF209D, CF211D, CF212D, CF216D, CF218D, CF222D, CF225D, CF227D and CF228D, which collectively have a total of 45 sampling ports (also referred to as sampling intervals). Two samples were collected from the screened interval in the six conventional bedrock monitoring wells installed over the course of the RI. The six conventional (single-depth) bedrock monitoring wells are CF205D, CF223D, CF224D, CF226D, CF229D and CF230D.

Samples were also collected from six bedrock monitoring wells installed by others prior to the RI; wells CF10D, CF11D, CF22S, WRA2-1, WRA3-2 and WRA3-3. A review of the well construction information for these wells confirmed that they had been constructed in accordance with NJDEP regulation (NJDEP 2007).

HDR re-sampled six wells, CF201D, CF206D, CF207D, CF212D, CF218D and CF222D, in July 2015 as the previous VOC analytical results for the samples from these wells were rejected by the data validator.

A total of 142 groundwater samples were collected.[1] Sampling locations are identified on Figure 2-1.

Groundwater samples were analyzed for EPA's target compound/analyte list (TCL/TAL) VOCs, semi-volatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs) and metals; cyanide, total suspended solids (TSS), total dissolved solids (TDS), total organic carbon (TOC) and chloride.

The usability of the groundwater data is evaluated in the DER; groundwater impacts are evaluated in the BHHRA with data that meet DQIs and are deemed appropriate for use in the risk assessment. More detail is provided in the DER.

Seeps and springs, which are expressions of groundwater quality, are found across OU2 and identified on Figure 2-1, which depicts these and groundwater sampling locations. Groundwater discharges to the land surface via seepage into streams, ponds and wetlands; for example, groundwater surfacing at seeps constitutes the head waters of Trout Brook. A review of the source, location and characteristics of nearby seeps and springs indicates there is evidence that the spring in the southwest corner of a pond on the 21 Schoolhouse Lane property is hydraulically connected to well CF206D (HDR 2015e). Seeps and springs will not be evaluated separately in the BHHRA since they are considered part of groundwater and exposure to COPCs at seeps/springs is considered *de minimis* (EPA 2015d, HDR 2015 d and e).

3.2 Surface Water

OU2 is largely an evaluation of groundwater in the deep aquifer; however, as there is groundwater flow to surface water that may impact water quality and therefore, human receptors, surface water data are considered in the BHHRA.

The interaction of groundwater and surface water was investigated at nine locations along the nearby streams and a wetland to correlate groundwater and surface water elevations and determine if potentially contaminated groundwater is discharging to

[1] The groundwater samples count excludes samples collected during packer testing and from wells not meeting N.J.A.C. 7:9D requirements, as noted in Section 3.5.2.

surface waters. A site reconnaissance was conducted to identify depositional areas in the streams and possible groundwater upwelling locations prior to sampling.

HDR conducted surface water sampling in November 2014; the sampling locations are identified on Figure 2-2. There were 26 samples (including two field duplicates) collected along four streams with headwaters near the landfill, i.e., Trout Brook, East Trout Brook, the Lamington River UNT and Tanners Brook UNT.

East Trout Brook data were segregated and evaluated separately in the COPC screening to determine if there are any impacts to surface water quality from the treatment plant effluent discharge into this stream.

Surface water samples were analyzed for TCL/TAL VOCs, SVOCs, pesticides, PCBs and metals (total and dissolved), cyanide, TSS, TDS, TOC, alkalinity and chloride.

The usability of the surface water data is evaluated in the DER; data that meet the DQIs and deemed appropriate for risk assessment are included in the BHHRA to evaluate surface water impacts. More detail is provided in the DER.

3.3 Sediment

As with surface water, flow from groundwater to surface water and therefore, to sediment necessitated that sediment data be collected and considered in the data evaluation for inclusion in the BHHRA.

HDR conducted sediment sampling in November 2014. There were 26 samples (including two field duplicates) collected along the same four streams noted above and the sampling locations are identified on Figure 2-2. The East Trout Brook sampling locations are downstream of the landfill's groundwater treatment plant effluent discharge. The sediment data were used to evaluate any impacts to sediment quality from the effluent discharge.

Sediment samples from 0.0 to 0.5 feet deep in the stream bed were analyzed for TCL/TAL SVOCs, pesticides, PCBs and metals, cyanide, TOC, grain size, percent moisture and pH. VOCs were not analyzed in these samples because of the increased loss of VOCs from surficial sediment. Sediment samples from 0.5 to 1.0 feet below the stream bed were analyzed for TCL VOCs and moisture content.

The usability of all sediment data is evaluated in the DER; data that meet the DQIs and deemed appropriate for risk assessment are considered for inclusion in the BHHRA. More detail is provided in the DER.

In accordance with EPA guidance and for this risk assessment, sediment constituent concentrations were compared to and found to be below the NJ Residential Direct Contact Soil Remediation Standards (RDCSRS), with the exception of arsenic, at a maximum detected concentration of 20 milligrams per kilogram (mg/kg, NJ RDCSRS is 19 mg/kg) and benzo(a)pyrene at a maximum of 0.34 mg/kg (NJ RDCSRS is 0.2 mg/kg).

A review of the potential for bioaccumulation of primary constituents 1,4-dioxane, chlordane, arsenic and lead indicates that chlordane, arsenic and lead are all considered to be bioaccumulative; under what conditions and at what point in the food chain varies. The constituent 1,4-dioxane is not considered to be bioaccumulative, but is persistent; it does not degrade easily or quickly in the environment (HDR 2015a).

The site is less accessible and attractive than other recreational areas in the vicinity; use by recreators and exposure to environmental media in OU2 would be low.

Upon review of the sediment data, site use and conditions, potential for bioaccumulation, and exposure pathways, it was determined that minimal and infrequent contact with sediment is expected; therefore, sediment is not evaluated in the BHHRA (EPA 2015d, 2016).

3.4 Soil

None of the soil data were used in the COPC screening and risk estimates for soil exposure will not be evaluated in the BHHRA; on-site soil is largely landfill perimeter road fill and is not indicative of constituent concentrations in OU2 soil. Further, soils were addressed as part of the landfill cap remedy in OU1. The purpose of the OU2 RI/FS is to characterize the nature and extent of deep aquifer groundwater contamination, which is not in contact with soil, and the potential exposure and risk resulting from that contamination.

3.5 Data Refinement

Data that were determined appropriate for use in the risk assessments were refined for use in the BHHRA.

3.5.1 General Refinements

In accordance with EPA Guidance for Data Useability in Risk Assessment (Part A; EPA 1992):

- Chemical concentrations qualified as not detected (i.e., U-qualified data) are evaluated as non-detects. Concentrations qualified as estimated (i.e., J-qualified data) are included for quantitative assessment. Rejected R-qualified data are not used.
- The sample quantitation limit (QL) is used to represent non-detect results. Note that ProUCL applies the Regression on Order Statistics (ROS) methods for lognormal and gamma distributed data sets to provide a better estimate of the non-detected sample's true value based on actual detected concentrations. For normal distributions, ProUCL utilizes Kaplan-Meier estimates in lieu of the ROS methods because the ROS methods tend to yield biased and negative non-detect values (EPA 2013b and c).
- The maximum of the normal and field duplicate sample pairs is used if both are detected. The detected value is used when one result was detected and the other non-detect.
- The concentrations of specific isomers or Aroclors™ are evaluated individually instead of summing the results to calculate a result for the total. This applies to the following constituents:
  - Endosulfan I and endosulfan II
  - M,p-xylene and o-xylene

- Cis and trans 1,3-dichloropropene
- Alpha and gamma chlordane
- PCB Aroclors™

3.5.2 Data Refinements Using EPA "Core of the Plume Guidance"

Certain groundwater data are excluded to meet the requirements in the EPA memorandum titled *Determining Groundwater Exposure Point Concentrations, Supplemental Guidance* (referred to herein as the "Core of the Plume Guidance", EPA 2014a). This memorandum specifies which groundwater data are acceptable for calculating the exposure point concentrations based on the type of well sample (e.g., monitoring well) and data quality (e.g., low turbidity). The groundwater data excluded from the BHHRA are summarized as follows (HDR 2015b, EPA 2015a):

- Several of the NJDEP-owned wells sampled by HDR do not meet the Department's well construction requirements (NJDEP 2007); the data associated with these wells have been eliminated from the data set as potentially having inferior data quality.
- The samples taken during packer testing from open boreholes, prior to completion with Water FLUTe™ wells and that were used for screening purposes only to determine the final well completion depths are excluded. These samples were not collected using low flow techniques. As 1,4-dioxane is the primary analyte of interest and it is a VOC, the data cannot be relied upon for risk assessment purposes.
- NJDEP-owned wells that are not placed in competent bedrock or screened in overburden are excluded from the data set as they are outside the scope of OU2.

3.6 Identification of COPCs

The COPC screening tables are presented in the format of RAGS Part D Planning Tables (EPA 2001) in Attachment A, Tables 2.1 through 2.3. Table 2.1 presents the COPC screening of groundwater, Table 2.2 that of surface water and Table 2.3 that of surface water downstream of the leachate treatment plant (i.e., East Trout Brook data).

COPCs were determined in accordance with the criteria included in Chapter 5 of EPA RAGS Part A (EPA 1989) as follows:

- A constituent that is detected in fewer than five percent of the samples is eliminated as a COPC if a sufficient number of samples are collected for analysis. According to RAGS, Part A (EPA 1989), at least 20 samples are needed in the data set if a frequency of detection limit of 5 percent is used as one criterion for eliminating compounds from further consideration in the BHHRA. For this COPC screening, groundwater had 31 constituents with less than five percent detection and at least 20 samples were collected for these constituents; thus, they are determined not to be COPCs in groundwater – see Attachment A, Table 2.1.
- Constituents are excluded from the COPC list if they are essential nutrients and are present at levels not likely to pose appreciable risk to human health as per RAGS, Part A (EPA 1989). Chemicals that are considered to be essential nutrients include iron, calcium, chloride, magnesium, potassium and sodium. Iron and sodium are

retained as COPCs in groundwater since their maximum concentrations are greater than the screening levels – see Attachment A, Tables 2.1 and 2.2.

- Analytical data results that are not chemical-specific (e.g., TOC) are excluded from the COPC list.
- Tentatively identified compounds (TICs) are generally excluded from the COPC screening. TICs associated with pharmaceuticals and personal care products (PPCPs) is discussed, along with toxicity information, in the Uncertainty section of the BHHRA (EPA 2015d, HDR 2015g).

For the remaining constituents, the maximum detected concentrations of these constituents in groundwater and surface water are compared to screening levels to assess the potential for adverse impact to human health and to identify COPCs. Exceedances of screening levels do not in themselves indicate that an unacceptable exposure exists. Rather, the exceedance of a screening level indicates the need for further evaluation in the BHHRA.

- Groundwater maximum detected concentrations are compared to EPA Regional Screening Levels (RSLs) for Residential Tapwater at a target cancer risk of 1E-06 and target noncancer hazard quotient (HQ) of 0.1 (EPA 2015f). They are also compared to NJDEP Groundwater Quality Standards (NJDEP 2010), which include the NJ Interim Generic and Specific criteria (NJDEP 2015).
- Surface water maximum detected concentrations are compared to NJDEP Surface Water Quality Standards Fresh Water (FW2) Human Health (NJDEP 2011) and EPA RSLs for Residential Tapwater (EPA 2015f, HDR 2015d).

If the maximum detected concentration of a constituent was less than the screening level, it was eliminated as a COPC, as it is assumed it will not contribute significantly to potential unacceptable risk (EPA 1989). Constituents without a screening level are retained for further quantitative evaluation in the BHHRA.

The COPC screening resulted in 29 COPCs identified in groundwater and surface water. For groundwater, 10 VOCs, 13 inorganics, one geochemical and two each for SVOCs and pesticide constituents are identified as COPCs. For surface water from Trout Brook, Lamington River UNT and Tanners Brook UNT, two VOCs and seven inorganic constituents are identified as COPCs. For surface water downstream from the leachate treatment plant (i.e., East Trout Brook), one VOC, one pesticide and two inorganic constituents are identified as COPCs.

The COPCs are presented in Table 3-1 below as well as in Attachment A, RAGS Part D Planning Table 2.Supp.1.

Table 3-1. Constituents of Potential Concern

Constituent Group	Constituent	Groundwater	Surface Water	Surface Water Downstream of Leachate Treatment Plant
VOC	1,2-dichloroethane	x		
VOC	1,2-dichloropropane	x		
VOC	1,4-dichlorobenzene	x		
VOC	1,4-dioxane	x	x	x
VOC	Benzene	x		
VOC	Chloroform	x		
VOC	Cis-1,2-dichloroethylene	x		
VOC	Diethyl Ether (Ethyl Ether)	x		
VOC	Tetrachloroethylene (PCE)	x		
VOC	Trichloroethylene (TCE)	x	x	
SVOC	Bis(2-ethylhexyl) Phthalate	x		
SVOC	Caprolactam	x		
PEST	BHC alpha	x		
PEST	Chlordane, alpha			x
PEST	Endrin Aldehyde	x		
INORG	Aluminum	x	x	
INORG	Arsenic	x	x	x
INORG	Barium	x		
INORG	Beryllium	x		
INORG	Chromium, Total	x		
INORG	Cobalt	x	x	
INORG	Copper	x		
INORG	Iron	x	x	
INORG	Lead	x	x	
INORG	Manganese	x	x	x
INORG	Nickel	x		
INORG	Sodium	x		
INORG	Vanadium	x	x	
Geochemical	Chloride (as Cl)	x		

4 Exposure Assessment

The objective of the exposure assessment is to estimate the magnitude, frequency, duration and routes of current and reasonably anticipated future human exposure to COPCs associated with the site. The exposure assessment is based on the receptor scenarios for Site-related COPCs via site-specific routes of exposure.

The standard default exposure factors recommended by EPA for estimating reasonable maximum exposure (RME) are used where available and appropriate. Where standard default exposure factors are not available for an exposure pathway, the evaluation is conducted using similarly conservative exposure factors that are based on site-specific considerations and professional judgment.

This section presents a CSM that identifies the exposure pathways and the potentially exposed receptors. It also describes the receptors and exposure pathways and if they will be evaluated quantitatively and qualitatively and the rationale for each.

4.1 Site Conceptual Model

The CSM is a dynamic tool for understanding site conditions and potential exposure scenarios for human receptors that may be exposed to site-related contamination. An exposure pathway consists of:

- A source (e.g., landfill) and mechanism of constituent release from source;
- A retention or transport medium (e.g., groundwater) for the constituent;
- A point of contact (e.g., drinking water) between the human receptor and the medium; and
- A route of exposure (e.g., ingestion) for the potential human receptor at the contact point.

An exposure pathway is considered complete only if all four components are present. In the BHHRA, only complete exposure pathways will be evaluated quantitatively. A schematic presentation of the CSM is included as Figure 3-1 and in a tabular format in Attachment A, RAGS Part D Planning Table 1.

4.2 Receptors

Potential receptors are defined as human populations that are subject to contaminant exposure. Both current and future land- and water-use conditions are considered when determining exposure scenarios. Current land-use consists primarily of low-density residential (lot sizes are generally more than two acres) amidst large parcels of cleared or forested rolling hills. Some of the larger parcels are used for agricultural purposes. Future land use is expected to remain predominantly residential with limited agriculture. Therefore, the following potential receptors are identified: current/future adult and child resident and current/future adult and child recreational user. These receptors are depicted in diagram format on Figure 3-1 and in tabular format in Attachment A, RAGS Part D Planning Table 1.

4.2.1 Current/Future Resident (Adult/Child)

The potential for residents to be exposed to COPCs in groundwater is included in the BHHRA, in accordance with the EPA memorandum titled *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions* (EPA 1991b), which requires the assumption of no treatment of the water source and no institutional (e.g., restrictive ordinances) or engineering (e.g., point of entry treatment) controls. Potable residential wells northeast of the site have been impacted with constituents that have migrated off-site from the landfill (HDR 2011b). Actual exposure is expected to be limited, as the 1986 ROD called for an alternate water supply (HDR 2011b) and a municipal water supply was recently constructed to serve properties impacted by groundwater contamination (EPA 2015b). Risks potentially associated with ingestion and dermal contact of organics and inorganics from tap water; and the inhalation of VOCs in groundwater by residents during showering will be evaluated in the BHHRA.

4.2.2 Current/Future Recreational User (Adult/Child)

Recreational users may incidentally ingest or come into contact with surface water while visiting Trout Brook, East Trout Brook, the Lamington River UNT and Tanners Brook UNT, which are presented on Figure 2-2.

Recreational users may ingest fish in nearby Trout Brook that is classified as trout-production [FW2-TP(C1)], trout-production East Trout Brook [FW2-TP(C1)] and trout-maintenance Lamington River UNT [FW2-TM(C1)] (NJDEP 2005, 2011). Tanners Brook is classified by NJDEP as non-trout water [FW2-NT(C1)] (NJDEP 2005, 2011); however, other consumable fish may be present. A review of fish species that are potentially present indicates there are 17 fish species in the Lamington River UNT, which is the largest of the four water bodies and is most likely where fish are present. Of these species, only four species are considered consumable, i.e., white sucker, American eel, brown trout and sunfish (HDR 2015d). Both Trout Brook and Tanners Brook discharge to the Lamington River.

The water bodies have relatively small local watersheds and are headwater streams with moderate relief tributaries. Based on field observations, most of these streams have an ecological community classification of a marsh headwater stream, which consists of small marshy perennial brooks with very low gradients, slow flow rate (<35 feet per second) and cool to warm water that flows through a marsh, fen or swamp where a stream system originates. These water bodies have clearly distinguished meanders or high sinuosity, and are in unconfined watersheds (Edinger et. al, 2002).

The Lamington River UNT is 17 to 80 feet wide and its depth ranges from less than six inches to seven feet based on land surveys performed for the site.[2] The headwaters consist of a ditch running parallel to the power lines easement and the pond at 21 Schoolhouse Lane. The Lamington River UNT runs easterly through wooded sections of a number of residential properties along Schoolhouse Lane and then bends northeast towards the confluence with the Lamington River at County Route 513. The characteristics of the other three water bodies were based on field observations, aerials and online information: Trout Brook is three to four feet wide, has a depth of less than six inches to approximately two feet deep. East Trout Brook is approximately two feet wide, has a depth of less than six inches and has steep banks that make for a well-defined stream channel. Tanners Brook UNT is approximately one foot wide and has a depth of less than six inches (HDR 2015f).

Upon review of the sediment data, site use and conditions, potential for bioaccumulation, and exposure pathways, it was determined that minimal and infrequent contact with sediment is expected; therefore, sediment is not evaluated in the BHHRA (EPA 2015d, 2016).

Recreational users may come into contact with seeps and springs that are expressions of groundwater along Schoolhouse Lane. However, no water data was collected from these sources; actual groundwater data are being evaluated instead. The evaluation of risk resulting from a resident's use of untreated deep groundwater as tapwater and including ingestion, dermal contact and inhalation routes is expected to be protective of the much less intensive recreational exposure to deep groundwater expressed as

[2] The stream segment 80 feet in width and seven feet in depth was measured at one of the ponds.

seeps/springs (EPA 2015g). The exposure to COPCs in seeps/springs is considered *de minimis* and will not be evaluated in the BHHRA (EPA 2015d).

4.3 Exposure Point Concentrations

Estimates of COPC concentrations at points of potential human exposure are necessary for evaluating chemical intakes by potentially exposed individuals. The concentrations of chemicals in the exposure medium at the exposure point are termed "exposure point concentrations" (EPC). The EPC for the BHHRA is defined as the 95 percent upper confidence limit (UCL) of the arithmetic mean or maximum observed concentration of an individual COPC, per media, whichever is lower. Calculation of the UCL will be conducted in accordance with EPA guidance (EPA 2002a, 2013b). The ProUCL software package, version 5.0.00 (2013b) is used to determine the underlying statistical distributions and the EPCs based on the characteristics of the data.

The EPCs for each medium in the exposure assessment will be calculated and presented in the RAGS Part D Planning Tables 3.1 through 3.3 of the BHHRA; the EPCs are not presented in this PAR.

4.4 Chemical Exposure Intake

The EPCs will be used in combination with exposure factors from EPA guidance and standard default parameters (EPA 2011a) to estimate chemical intake via each exposure pathway for each receptor. Some default exposure factors have been updated in the 2014 EPA Office of Solid Waste and Emergency Response (OSWER) Directive 9200.1-120 (EPA 2014b); these values will be incorporated where applicable.

Chemical intake is expressed in terms of milligrams of chemical per kilogram of body weight per day (mg/kg-day), using the following general equation, which will be adjusted based on the exposure pathway and medium:

$$Intake = \frac{EPC\ x\ IR\ x\ EF\ x\ ED}{BW\ x\ AT}$$

Where:

Intake	=	daily intake or exposure dose (mg/kg-day)
EPC	=	exposure point concentration of COPC [micrograms/liter (ug/L)]
IR	=	ingestion rate; the amount of contaminated medium ingested over the exposure period (L/day)
EF	=	exposure frequency; describes how often exposure occurs (days/year)
ED	=	exposure duration; describes how long exposure occurs (years)
BW	=	body weight; the average body weight over the exposure period (kg)
AT	=	averaging time; period over which exposure is averaged (days)

Each of the intake variables in the above equation consist of a range of values taken from RAGS, Part A through F (EPA 1989, EPA 2009) and other applicable risk guidance, e.g., the *Exposure Factors Handbook* (EPA 2011a). The exposure factors and intakes for receptor population groups for each exposure pathway are presented in Attachment A, RAGS Part D Planning Tables 4.1 and 4.2 and are summarized below. Table 4.1 describes in more detail the exposure factors for pathways related to groundwater. Table 4.2 describes the exposure factors related to surface water exposure scenarios.

4.4.1 Exposure Factors

The averaging time (AT) for cancer risk and body weight (BW) are the same for all exposure pathways, as follows:

- The averaging time for evaluating cancer risk is equal to a lifetime of 70 years or 25,550 days (EPA 2014b). The averaging time for evaluating noncancer hazard quotients is equal to the exposure duration, which varies by receptor (EPA 2014b).
- The body weight of 80 kg is the standard EPA-recommended body weight for assessing exposure to adults and 15 kg for children (EPA 2014b).

Ingestion Pathway of Exposure

- *Ingestion Rate*

  Residents are assumed to drink 2.5 L/day of groundwater-derived tap water as an adult and 0.78 L/day as a child, which are weighted averages of 90th percentile values for ingestion of drinking water (EPA 2014b).

  The incidental ingestion rate of surface water for a recreational user is assumed to be less, at 0.48 L/day for an adult, which is based on a mean recommended value of 20 milliliters/hour (mL/hour) for swimming in Table 3-5 of the *EPA Exposure Factors Handbook* (EPA 2011a, EPA 2015g). A child's incidental ingestion rate is considered to be higher, at 1.2 L/day, which is based on a 50 mL/hour value for swimming (EPA 2011a, EPA 2015g, EPA Region IV 2014).

- *Exposure Duration and Frequency*

  Resident adults are assumed to ingest groundwater-derived tap water for 350 days/year for 20 years (EPA 2014b). The same exposure frequency of 350 days/year is applied to a resident child, but for six years (EPA 2014b).

  The exposure duration for recreational users incidentally ingesting surface water is also six years for a child and 20 years for an adult (EPA 2014b). Recreational users are expected to have an exposure frequency of 108 days/year, which assumes the receptor visits surface water streams five days/week during summer (June, July, Aug) and three days/week during spring and fall (Apr, May, Sept, Oct). A sensitivity analysis will be performed in the BHHRA for a recreational user applying an exposure frequency of 52 days/year, which is based on two days per week in the summer (May, June, July, Aug) and one day per week in the spring and fall (Mar, Apr, Sept, Oct, Nov; EPA 2015d).

Fish Ingestion Pathway of Exposure

- *Ingestion Rate*

  A fish ingestion rate of 23.2 grams per day (g/day) is used for evaluating adult fish ingestion based on a regional fish and crab consumption survey of 267 adults who angled from the Newark Bay Complex (Burger 2002). Specifically, the rate is calculated by taking the mean yearly fish consumption (in grams) reported by Burger for only those individuals who angled and dividing it by 350 days. According to Burger (2002), this mean yearly fish consumption is the mean value for the 60% of the group who consumed their catch; it does not account for the 40% of the group who did not consume their catch. This ingestion rate is used to be consistent with the rate used in other similar published risk assessments in EPA Region 2. The fish ingestion rate for a child (age 0-6) is proportionally adjusted (1/3) from the adult ingestion rate to 7.73 g/day; the proportion is consistent with other published risk assessments in EPA Region 2 (EPA 2016, HDR 2016).

- *Exposure Frequency*

  The exposure frequency for fish ingestion is assumed to be 108 days per year for the recreational fisher, as explained above. A sensitivity analysis will also be performed in the BHHRA for recreational fishing, applying the same 52 days per year for this exposure pathway (EPA 2015d).

- *Surface Water to Fish Bioconcentration Factors (BCFs)*

  Since fish tissue samples were not collected, the chemical exposure intake for fish will be estimated using literature-derived BCFs. The BCF is the ratio of the constituent concentration in fish to the concentration in water. The BCFs (in units of L/kg) are taken from multiple sources using the following hierarchy:

  - EPA National Recommended Water Quality Criteria – Human Health Criteria Calculation Matrix (EPA 2002b)
  - DOE ORNL Risk Assessment Information System – Chemical Parameters Fish BCFs (DOE 2013)

  A surface water to fish BCF is not identified for vanadium and is assumed to be one, i.e., the fish tissue concentration is assumed to be equivalent to the media concentration. Discussion regarding the uncertainty of vanadium's BCF is described in Section 8 of the BHHRA. Attachment A, RAGS Part D Planning Table 4.Supp.5 presents the surface water to fish BCFs.

Dermal Contact Pathway of Exposure

- *Skin Surface Area*

  The skin surface area available for contact with water during showering for a resident is 19,652 square centimeters (cm^2) for an adult and 6,365 cm^2 for a child, which are the weighted averages of mean values for the surface area of the whole body (EPA 2014b). These values are greater than the skin surface area for contact with surface water, as it is assumed there will be more skin exposure to water during showering.

  The skin surface area for recreational contact with surface water is 10,070 cm^2 for an adult and 3,870 cm^2 for a child. The sum of mean values for arms, hands, legs and feet from Table 7-2 of the *Exposure Factors Handbook* (EPA 2011a) was calculated for each age group and then the maximum of these values was used as the surface area, which is presented in Attachment A, RAGS Part D Planning Tables 4.Supp.1 and 4.Supp.2.

- *Absorbed Dose per Event (DA-event)*

  The dermally absorbed dose per event (DA-event) from water contact is calculated using default equations and values presented in RAGS Part E (EPA 2004b). The following chemical-specific dermal factors are used in the calculation: dermal permeability constant (Kp), ratio of permeability coefficients (B), lag time per event (tau-event), time to reach steady state (t*) and fraction absorbed water (FA). The calculations for DA-event for each medium and scenario are presented in Attachment A, RAGS Part D Planning Tables 4.Supp.3A through 4.Supp.3D.

- *Event Duration (t-event) and Frequency*

  The event frequency is assumed to be one event per day for both groundwater and surface water exposures (EPA 2004b).

  The t-event for a resident showering is assumed to be 0.71 hour per event for an adult and 0.54 hour per event for a child, which are weighted averages of the 90th percentile spent bathing or showering in a day (EPA 2014b).

  The event duration for surface water contact is 2.6 hours per event, which is a commonly used value from RAGS Part A that is based on a national average for time spent swimming (EPA 1989). The *Exposure Factors Handbook* presents a similar range of UCL values, 160 to 180 minutes (2.6 to 3 hours), for swimming (EPA 2011a) and the time spent wading is assumed to be similar.

- *Exposure Duration and Frequency*

  Resident adults are assumed to come in dermal contact with groundwater-derived tap water for 350 days per year for 20 years (EPA 2014b). The same exposure frequency of 350 days per year is applied to a resident child, but for only six years (EPA 2014b).

  The exposure duration for recreational users coming in dermal contact with surface water is also six years for a child and 20 years for an adult (EPA 2014b). Recreational users are expected to have a conservative exposure frequency of 108 days per year, which assumes the receptor visits surface water streams five days per week during summer (June, July, Aug) and three days per week during spring and fall (Apr, May, Sept, Oct). A sensitivity analysis will be performed in the BHHRA for a recreational user applying an exposure frequency of 52 days per year, which is based on two days per week in the summer (May, June, July, Aug) and one day per week in the spring and fall (Mar, Apr, Sept, Oct, Nov; EPA 2015d).

Inhalation Pathway of Exposure

- *Concentration in Air (C_a)*

  The Andelman model as modified by Schaum et al. (Wang 1994) is used to estimate the chemical concentration in air (C_a) during time spent showering and in the bathroom. In the derivation of C_a, it is assumed that the volume of the bathroom is six cubic meters (m^3), the shower water flow rate is 1000 L per hour and the fraction of chemical concentration volatilized is 0.9, which are all based on upper estimates of the range of values presented in the Adelman model (Wang 1994). The calculations are presented in Attachment A, RAGS Part D Planning Tables 4.Supp.4A and 4.Supp.4B for the two groundwater scenarios (using the site-wide groundwater data set and the groundwater core of the plume data set).

The total exposure time for showering is 0.71 hour for an adult and 0.54 hour for a child (EPA 2014b). Since the Andelman model separates out exposure during showering from exposure while in the bathroom, professional judgment is used to split up the time spent for each in the calculation of the air concentration. For adult exposure, 15 minutes (min) for showering followed by 28 min in the bathroom, for a total of 43 min (0.71 hour) is assumed. For a child, approximately 20 min bathing followed by 13 min in the bathroom, for a total of 33 min (0.54 hour) is assumed. These values are consistent with the exposure time range identified in Table 1 of the Andelman model study (Wang 1994), EPA-recommended assumptions in Exhibit 3-2 of RAGS Part E (EPA 2004b) and fall within the range of estimates presented in Table 16-1 of the *Exposure Factors Handbook* (EPA 2011a).

- *Exposure Time*

  The exposure times for inhalation of groundwater-derived water vapor during showering are 0.71 hour per day for an adult and 0.54 hour per day for a child, which are weighted averages of the 90th percentile spent bathing or showering in a day (EPA 2014b).

- *Exposure Duration and Frequency*

  Resident adults are assumed to inhale shower water for 350 days per year for 20 years. The same exposure frequency of 350 days per year is applied to a resident child, but for only six years (EPA 2014b).

4.4.2 Age-Based Adjustments for Adult and Child

The BHHRA calculations incorporate age-adjustments for each COPC in the exposure intake term for calculating the cancer risk over the lifetime of a resident or recreational user as both a child and adult. For the ingestion exposure pathway, the adjusted ingestion rate is a summation of the individual ingestion rates weighted by the body weights and exposure durations of the receptor from birth to 26 years as described in the EPA RSL equations (EPA 2015e).

$$IR_{Adj} = \frac{\sum ED\ x\ IR}{BW}$$

Where:

IR-Adj = Adjusted ingestion rate (mg-year/day-kg)

ED = Exposure duration (year)

IR = Ingestion rate (mg/day)

BW = Body weight (kg)

For the dermal exposure pathway, the adjusted surface area is a summation of the individual surface areas weighted by the body weights and exposure durations of the receptor from birth to 26 years similar to the above equation.

The age-adjustment equations are presented in Attachment A, RAGS Part D Planning Tables 4.1, 4.2 and 4.Supp.1.

The inhalation exposure pathway does not require an age-adjustment as per RAGS Part F, Appendix A, Section 6.1 (EPA 2009).

4.4.3 Mutagen Adjustments for Early-Life Exposure

EPA has identified several carcinogens that act via a mutagenic mode of action (MMOA). To account for their early-life exposures, age-dependent adjustment factors (ADAFs) have been incorporated into the intake equation. This approach is consistent with the 2005 Guidelines for Carcinogen Risk Assessment (EPA 2005a) and the Supplemental Guidance for Assessing Susceptibility from Early Life Exposure to Carcinogens (EPA 2005b). The intake equations are described in the EPA RSL equations (EPA 2015e) and the equation for the ingestion exposure pathway is shown here:

$$IR_{Adj} = \frac{\sum ED \; x \; IR}{BW} \times ADAF$$

Where:

ADAF = Age dependent adjustment factors, where

0-<2 years applied an ADAF of 10,

2-<6 years applied an ADAF of 3,

6-<16 years applied an ADAF of 3, and

6-26 years applied and ADAF of 1.

For the dermal exposure pathway, the adjusted surface area is a summation of the individual surface areas weighted by the body weights and exposure durations of the receptor from birth to 26 years. The surface area is then multiplied by the ADAF, similar to the above equation.

The MMOA age-adjustment equations are presented in Attachment A, RAGS Part D Planning Tables 4.1, 4.2 and 4.Supp.2.

Exposure intakes for the mutagen trichloroethylene (TCE) incorporate specific calculations, as the toxicity assessment for TCE requires that we address the mutagenic effects on the kidney versus the standard cancer effects on the liver and potential for developing non-Hodgkin's lymphoma. To accomplish this, the mutagenic and standard cancer equations are combined. The different toxicity values for use in the cancer and mutagen intake equations are incorporated using a toxicity value adjustment factor for cancer (CAF) and mutagens (MAF) for all exposure pathways as described in the EPA RSL equations (EPA 2014) and in Tables 4.1 and 4.2.

4.4.4 Evaluation of Lead Intake

Exposure to lead is regulated based on blood lead concentrations instead of calculating chemical intakes and subsequent risk estimates. EPA has not established the toxicity values for lead intake that are necessary for calculating risk (EPA 2004a). EPA and the Centers for Disease Control and Prevention (CDC) have determined that childhood blood lead concentrations at or above 10 micrograms per deciliter (ug/dL) present adverse health effects. In January 2012, CDC recommended lowering the reference blood lead level to 5 ug/dL for children age one to five years (CDC 2012); however, 10 ug/dL will be used as the threshold for this BHHRA as EPA as not yet implemented CDC's recommendation (EPA 2015g). A discussion of a comparison of the blood lead concentrations to the 5 ug/dL level will be included in the Uncertainty section of the BHHRA.

Lead risks for children are assessed using the EPA Integrated Exposure and Uptake Biokinetic (IEUBK) blood lead model (EPA 2010). The IEUBK model is a computer-based model that estimates the blood lead concentration in children (under the age of seven) resulting from their exposure to lead in soil, dust, drinking water, diet and air. Specifically, the model estimates the intake and uptake of lead into the body and then uses biokinetic modeling to predict blood lead concentrations.

Lead is identified as a COPC in site-wide groundwater, groundwater using EPA Core of the Plume guidance and in surface water. IEUBK will be run for each of these data sets using model default values, including default soil, diet and air concentrations. Site-specific arithmetic mean lead concentrations will be input as the drinking water concentrations. The Guidance Manual for the IEUBK model recommends using arithmetic mean concentrations for input (EPA 1994, 2002c). The arithmetic mean groundwater concentrations used in the BHHRA are 11 ug/L for the evaluation of site-wide groundwater, 47 ug/L for the evaluation of the refined groundwater data set using EPA Core of the Plume guidance, and 7.3 ug/L for evaluation of surface water.

As identified in the CSM and noted in Section 4.4.1, recreators are expected to incidentally ingest untreated surface water as opposed to intentionally drinking the water; further discussion on the uncertainty of evaluating surface water lead concentrations in the IEUBK model is presented in the Uncertainty section of the BHHRA.

5 Toxicity Assessment

The toxicity assessment provides a framework for characterizing the relationship between the magnitude of exposure to a COPC and the nature and likelihood of adverse health effects that may result from such exposure. For all exposure pathways, there are two approaches for deriving toxicity values. One involves the derivation of a noncancer reference value, i.e., an oral or dermal reference dose (RfD) and inhalation reference concentration (RfC), while the other involves derivation of a predictive cancer risk estimate, i.e., an oral or dermal cancer slope factor (CSF) and inhalation unit risk (IUR). An overview of the hierarchy to apply toxicity values is described in Section 5.1. The methodology that is used to develop a toxicity assessment as part of the BHHRA is provided in Sections 5.2 and 5.3.

5.1 Sources of Toxicity Values

Pertinent toxicological information on COPCs is selected from the following sources, in descending order of hierarchy, in accordance with EPA's OSWER Directive 9285.7-53, *Human Health Toxicity Values in Superfund Risk Assessments* (EPA 2003):

- Tier 1 – EPA's Integrated Risk Information System (IRIS) (EPA 2015c).
- Tier 2 – EPA's Provisional Peer Reviewed Toxicity Values (PPRTVs) – The Superfund Health Risk Technical Support Center (STSC) develops PPRTVs on a chemical specific basis when requested by EPA's Superfund program (EPA 2014c).
- Tier 3 – Other Toxicity Values – Tier 3 includes additional EPA and non-EPA sources of toxicity information (ATSDR 2014, Cal EPA 2007 and EPA 2011b). Priority is given to sources of information that are the most current, transparent, publicly available and those which have been peer reviewed.

The EPA RSL tables provide toxicity values following the above hierarchy; therefore, the November 2015 RSL summary table is used as the source of toxicity values for the PAR.

The cancer and noncancer toxicity values for the COPCs that are used in the risk assessment are presented in Attachment A, RAGS Part D Planning Tables 5.1 through 6.2.

Since chromium (total), identified as a COPC in groundwater, does not have toxicity values, the cancer and noncancer toxicity values for hexavalent chromium are input as conservative surrogates. A discussion of the uncertainty with use of hexavalent chromium's toxicity values in comparison to trivalent chromium's toxicity values and the resulting risk estimates will be presented in the Uncertainty section of the BHHRA.

5.2 Evaluation of Non-Carcinogenic Effects

Non-carcinogenic toxicity values are expressed as an oral reference dose (RfD) and inhalation reference concentrations (RfC). The RfD is typically provided in units of mg/kg-day. A RfC is provided for the concentration in the air, as mg/m^3.

In the current absence of dermal slope factors, EPA has devised a process that utilizes the dose-response relationship obtained from oral administration studies and makes an adjustment for absorption efficiency to represent the toxicity factor in terms of absorbed dose, using route-to-route (oral-to-dermal) extrapolations for systemic effects. This is performed using a chemical-specific oral absorption factor (GIABS) that accounts for the fact that most slope factors are expressed as the amount administered per unit time and body weight, with exposure estimates for the dermal pathway expressed as a dose absorbed in the gastrointestinal tract (EPA 1989, 2004b).

In the calculation of these toxicity values, EPA uses values (i.e., No Observable Adverse Effect Levels [NOAELs] and Lowest Observable Adverse Effect Levels [LOAELs]) that express the potential non-carcinogenic effects to identify thresholds for each chemical, and derive an estimate of the exposure below which adverse health effects are not expected to occur over a lifetime.

Two types of noncancer toxicity values are available from EPA depending on the length of exposure being evaluated (i.e., chronic or sub-chronic). Chronic toxicity values are specifically developed to be protective for long-term exposure to a compound, and are generally used to evaluate the non-carcinogenic effects associated with exposure periods between seven years and a lifetime. Sub-chronic toxicity values are useful for characterizing potential non-carcinogenic effects associated with shorter-term exposures. A combination of chronic and sub-chronic toxicity values are presented in the November 2015 RSL summary table, which is used as the source of toxicity values for this BHHRA.

The noncancer toxicity values for the COPCs that will be used in the BHHRA are presented in Attachment A, RAGS Part D Planning Tables 5.1 and 5.2

5.3 Evaluation of Carcinogenic Effects

Carcinogenic risks associated with a given level of exposure to potential carcinogens are typically extrapolated based on slope factors or unit risks. Oral slope factors are the upper 95th percent confidence limit of the slope of the dose-response curve, expressed in terms of risk per unit dose [$(mg/kg\text{-}day)^{-1}$]. Inhalation unit risks similarly relate the risk of cancer development with the concentration of carcinogen [$(mg/m^3)^{-1}$].

In the absence of dermal toxicity values for cancer development, EPA uses the oral dose-response relationship obtained from oral administration studies and adjusts for absorption efficiency with a GIABS factor to derive an absorbed dose in order to assess dermal exposure impacts for cancer, which is described in Section 5.2 above (EPA 1989, EPA 2004b).

The cancer toxicity values for the COPCs that will be used in the BHHRA are presented in Attachment A, RAGS Part D Planning Tables 6.1 and 6.2.

For constituents that EPA assessed prior to publication of the 2005 Guidelines for Carcinogen Risk Assessment (EPA 2005a), EPA considers those belonging to the following cancer weight of evidence groups to be human carcinogens (EPA 1986):

- Group A – Known Human Carcinogen – Sufficient evidence of carcinogenicity in humans;
- Group B1 – Probable Human Carcinogen – Limited evidence of carcinogenicity in humans;
- Group B2 – Probable Human Carcinogen – Sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans; and
- Group C – Possible Human Carcinogen – Limited evidence of carcinogenicity in animals and inadequate or lack of evidence in humans.

For constituents that EPA assessed after the 2005 Guidelines were published, EPA uses a narrative approach to characterize carcinogenicity (EPA 2005a):

- Carcinogenic to Humans
- Likely to be Carcinogenic to Humans
- Suggestive Evidence of Carcinogenic Potential
- Inadequate Information to Assess Carcinogenic Potential

As shown in Attachment A, RAGS Part D Planning Tables 6.1 and 6.2, few of the COPCs are designated as Group A or as being "Carcinogenic to Humans;" most are considered B1 or "Probable Human Carcinogens". Thus, evaluating these constituents as human carcinogens in the BHHRA is likely to be conservative.

6 Hazard Identification and Risk Characterization

The information obtained from the exposure assessment (see Section 4) and toxicity assessment (Section 5) will be integrated to identify the potential non-carcinogenic hazard and characterize excess lifetime cancer risk (ELCR) posed by COPCs selected for evaluation in the BHHRA. The risk associated with exposure to individual COPCs is described, and then the risk associated with exposures to multiple COPCs is characterized.

6.1 Non-Carcinogenic Hazard Identification

Potential risks for non-carcinogenic effects are typically estimated by calculating the HQ for each COPC using the following general equation, which can vary by exposure pathway:

$$HQ = \frac{Intake}{Toxicity}$$

Where:

HQ	=	Hazard quotient (unitless)
Intake	=	Chronic daily intake of chemicals or exposure dose (mg/kg-day or mg/m^3)
Toxicity	=	Oral reference dose (mg/kg-day), dermal reference dose (mg/kg-day) or inhalation reference concentration (mg/m^3)

The cumulative noncancer hazard index (HI) from exposure to the combination of COPCs in an environmental medium and also across all media for a receptor is estimated using the following equation (EPA 1989):

$$Hazard\ Index = \sum_i HQ_i$$

When the HI for a COPC exceeds unity (one), there may be concern for potential noncancer effects from that COPC. The HI is an indicator that potential hazard for a specific receptor exposed to a COPC in the environment cannot be ruled out, if it is greater than one, not that hazard actually exists. In interpreting HI values, it is important to understand that the values are estimates, based on predictive models, and are subject to the uncertainties inherent in both the estimates of exposure and toxicity benchmarks. The approach of summing noncancer hazard quotients across constituents and media may overestimate the noncancer HI because constituents may target different organs in the body and have varying noncancer health effects. Therefore, HI values should be viewed as one factor in a weight-of-evidence along with the results of other assessments (e.g., direct observations on the structure and function of the receptor community).

6.2 Carcinogenic Risk Characterization

Potential risks for carcinogenic effects are typically estimated by calculating an ELCR as a result of exposure to site-related carcinogens. Calculation of an ELCR for an exposure pathway involves multiplying the chronic daily intake for each chemical by its upper-bound cancer slope factor, as described by the following general equation (EPA 1989), which can vary by exposure pathway and COPC:

$$Risk = Intake \times Toxicity$$

Where:

Risk	=	Cancer risk (unitless)
Intake	=	Chronic daily intake of chemicals (expressed in mg/kg-day)
Toxicity	=	Oral slope factor [(mg/kg-day)$^{-1}$], dermal slope factor [(mg/kg-day)$^{-1}$] or inhalation unit risk [(ug/m^3)$^{-1}$]

The cumulative cancer risk from exposure to the combination of constituents in an environmental medium and also across all media for a receptor is estimated following EPA guidance (EPA 1989) and the following general equation:

$$Cumulative\ Risk = \sum_i Risk_i$$

For known or suspected carcinogens, EPA considers acceptable exposure levels to generally be concentration levels that represent an ELCR to an individual of between one in ten thousand (1E-04) and one in a million (1E-06). As with the noncancer HI, cumulative cancer risk is an indicator that potential risk for a specific receptor exposed to a COPC in the environment cannot be ruled out, not that risk actually exists.

7 References

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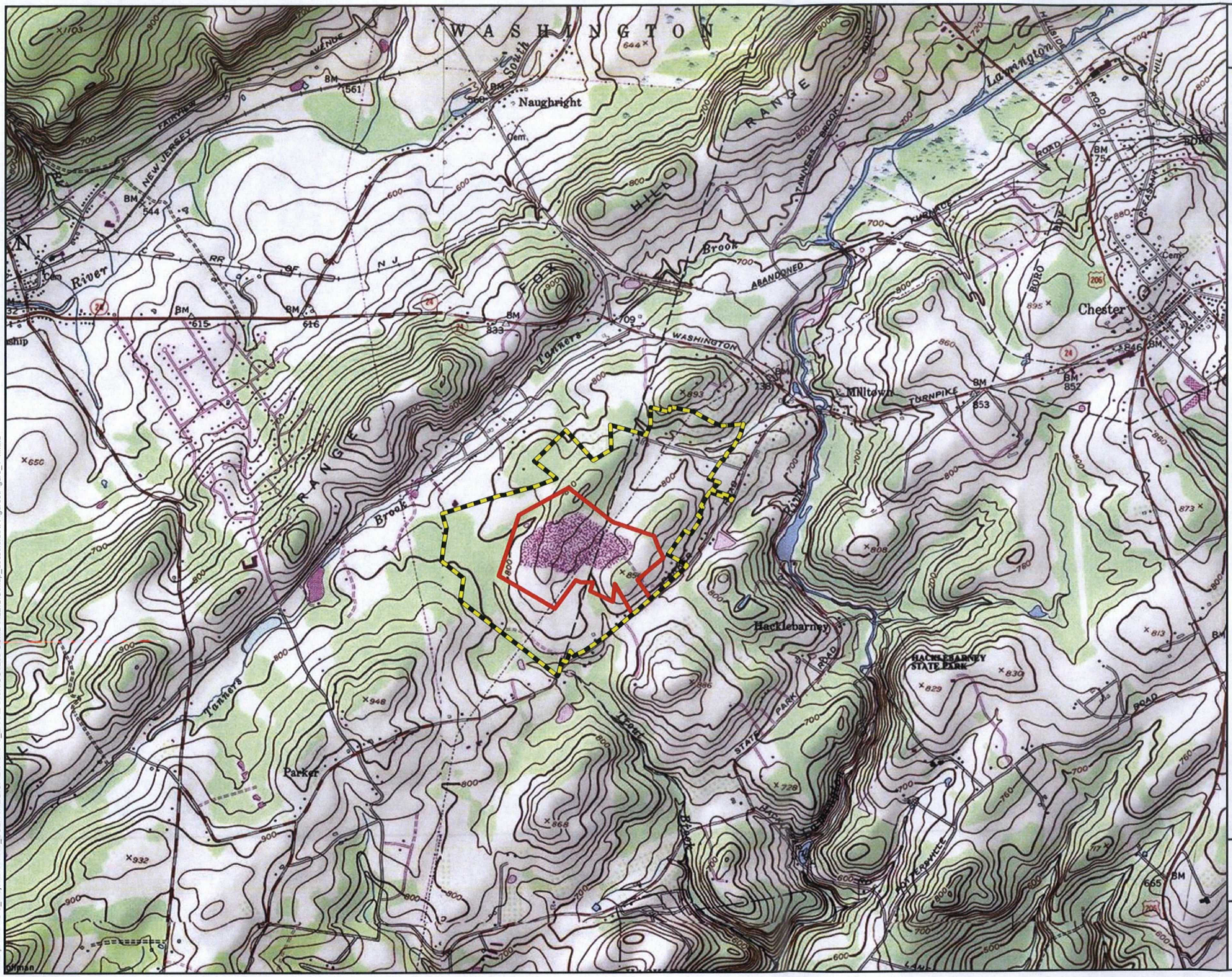
Figures

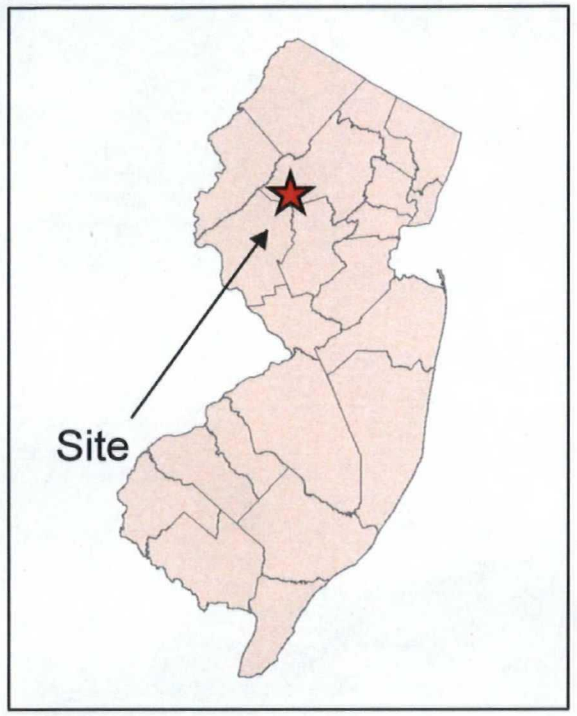
HDR

Combe Fill South Landfill Superfund Site OU2 RI/FS

Service Layer Credits: Copyright:© 2013 National Geographic Society, i-cubed

Coordinate System: NAD 1983 StatePlane New Jersey FIPS 2900 Feet
Projection: Transverse Mercator
Datum: North American 1983
Units: Foot US





Legend

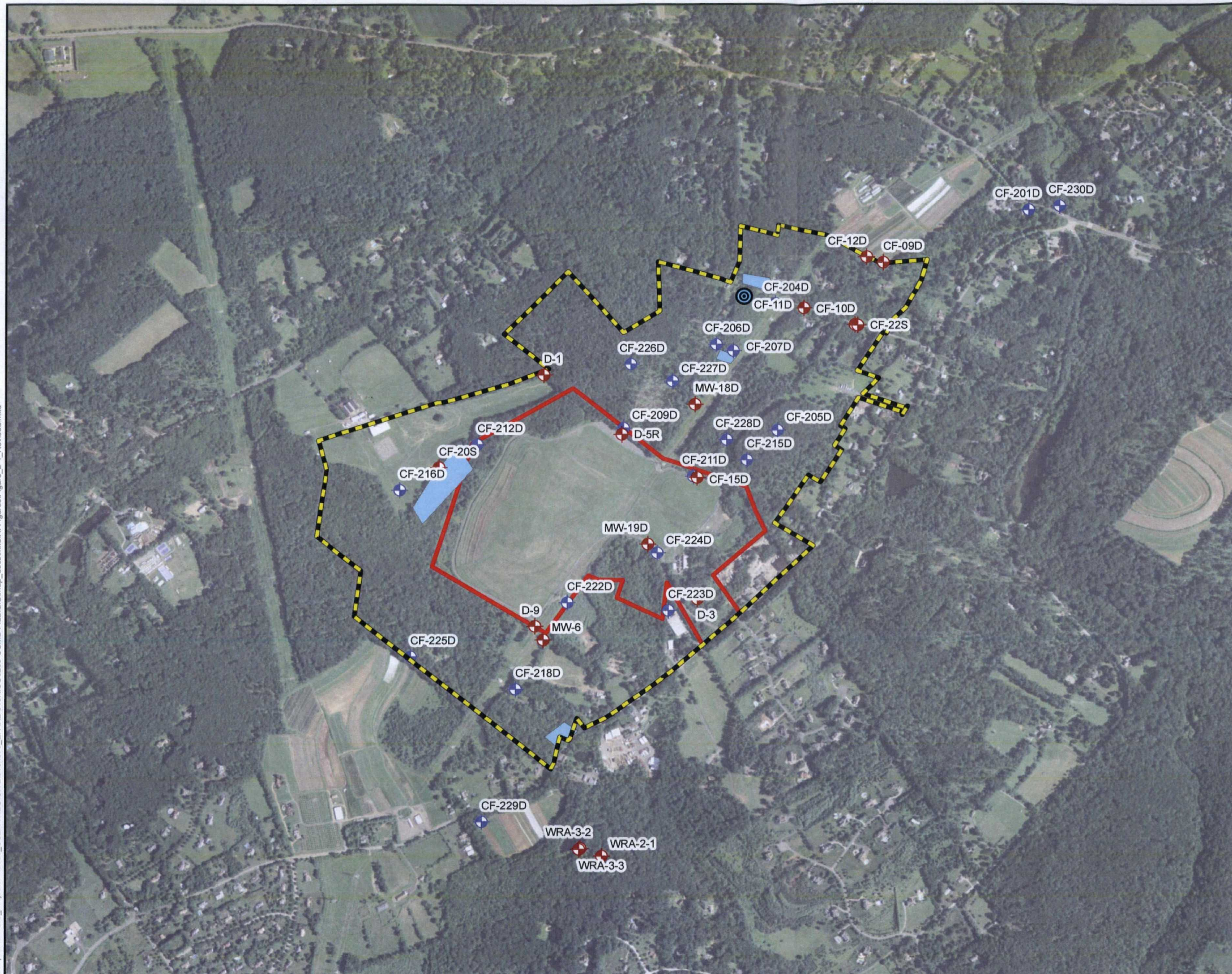
OU2 Boundary

Landfill Boundary

0 1,000 2,000 Feet

Site Location and Overview

Figure 1-1
February, 2016



HDR

Combe Fill South Landfill Superfund Site OU2 RI/FS

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Coordinate System: NAD 1983 StatePlane New Jersey FIPS 2900 Feet
Projection: Transverse Mercator
Datum: North American 1983
Units: Foot US

Legend

- OU2 Boundary
- Landfill Boundary
- OU 2 Bedrock Monitoring Wells
- NJDEP Subset Monitoring Wells
- Springs
- Seeps

0 500 1,000 Feet

N

Monitoring Well Locations Sampled Wells Only

Figure 2-1
February, 2016

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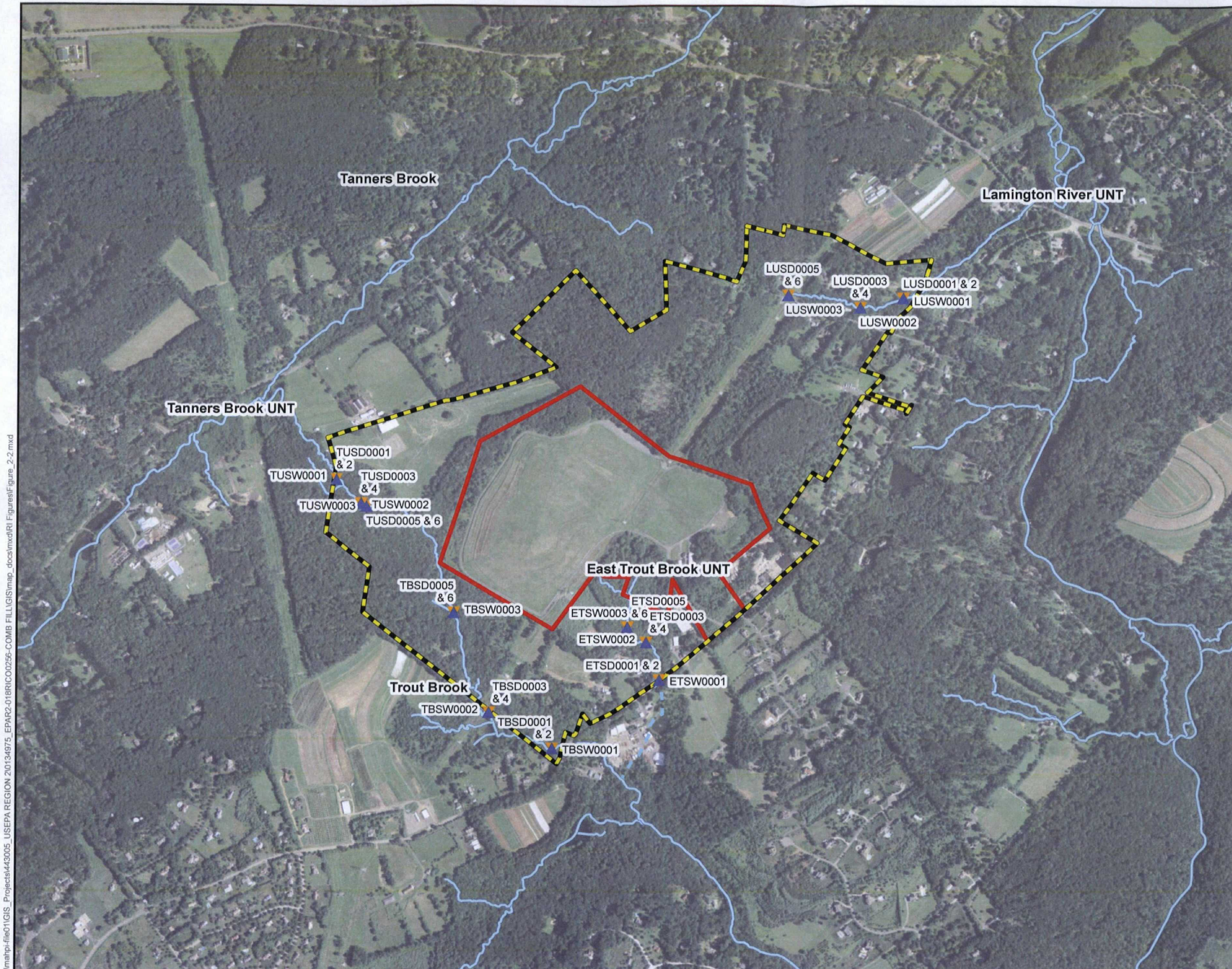

Combe Fill South Landfill Superfund Site OU2 RI/FS

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Coordinate System: NAD 1983 StatePlane New Jersey FIPS 2900 Feet
Projection: Transverse Mercator
Datum: North American 1983
Units: Foot US

Legend

- OU2 Boundary
- Landfill Boundary
- Surface Water Samples
- Sediment Samples
- East Trout Brook culvert

UNT = Unnamed Tributary

0 500 1,000 Feet

Surface Water / Sediment Sampling Locations

Figure 2-2
February, 2016

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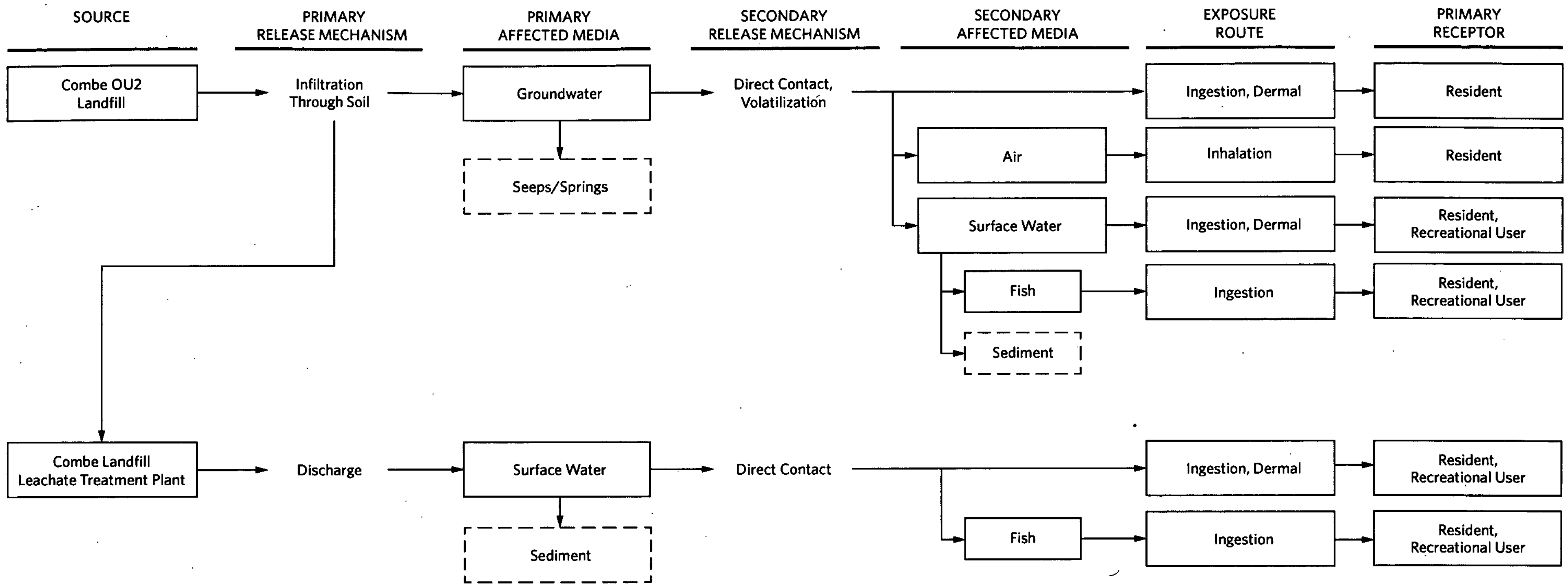

Legend:

Potentially Complete Exposure Pathway

Incomplete or Insignificant Exposure Pathway

Notes:

1. Exposure pathways are based on the current understanding of the Site and are subject to change.
2. Surface water will be evaluated for the nearby water bodies:
   Trout Brook, East Trout Brook, a Lamington River unnamed tributary (UNT) and a Tanners Brook UNT.
   East Trout Brook represents impacts downstream of the permitted discharge from the Treatment Plant.

U.S. Environmental Protection Agency
Combe Fill South Landfill OU2 RI/FS
Chester & Washington Townships, New Jersey

Figure 3-1
Human Health Conceptual Site Model
February, 2016

Attachment A

Contents:

TABLE 0
SITE RISK ASSESSMENT IDENTIFICATION INFORMATION
COMBE FILL SOUTH LANDFILL SITE OPERABLE UNIT 2
CHESTER AND WASHINGTON TOWNSHIPS, NJ

Site Name/OU:	Combe Fill South Landfill Site Operable Unit 2
Region:	2
EPA ID Number:	EP-W-09-009
State:	NJ
Status:	Remedial Investigation Report in progress
Federal Facility (Y/N):	N
EPA Project Manager:	Pamela Baxter
EPA Risk Assessor:	Lora M. Smith-Staines
Prepared by (Organization):	HDR
Prepared for (Organization):	EPA
Document Title:	Pathway Analysis Report
Document Date:	February 2016
Probabilistic Risk Assessment (Y/N):	N
Comments:	None

TABLE 1
SELECTION OF EXPOSURE PATHWAYS
COMBE FILL SOUTH LANDFILL SITE OPERABLE UNIT 2
CHESTER AND WASHINGTON TOWNSHIPS, NJ

Scenario Timeframe	Source	Receptor Population	Receptor Age	Medium / Exposure Medium	Exposure Point	Exposure Route	Type of Evaluation	Rationale for Selection or Exclusion of Exposure Pathway
Current/Future	Combe Fill South Landfill Site OU2	Resident	Adult	Groundwater	Tapwater	Ingestion	Quantitative	The deep aquifer is a major source of potable water in the vicinity of the site. Private residential wells northeast of the site have been impacted with chemicals that have migrated off site. Residents may come in contact with tapwater in the home and inhaling vapors volatilizing in the shower.
						Dermal		
					Air	Inhalation		
			Child	Groundwater	Tapwater	Ingestion	Quantitative	The deep aquifer is a major source of potable water in the vicinity of the site. Private residential wells northeast of the site have been impacted with chemicals that have migrated off site. Residents may come in contact with tapwater in the home and inhaling vapors volatilizing in the shower.
						Dermal		
					Air	Inhalation		
		Recreational User	Adult	Groundwater	Seeps/Springs	Ingestion	None	Recreational users may come into contact with seeps and springs that are present along Schoolhouse Lane. No water data was collected from these sources, actual groundwater data is evaluated, and exposure to seeps/springs is considered *de minimis;* therefore, this pathway is not evaluated. Resident exposure to deep groundwater as tapwater is expected to be protective of a recreational exposure to deep groundwater expressed as seeps/springs.
						Dermal		
				Surface Water	Surface Water	Ingestion	Quantitative	Recreational users may come into contact with surface water while visiting Trout Brook, the Lamington River UNT and Tanners Brook UNT.
						Dermal		
					Fish	Ingestion		Recreational users may ingest fish in nearby tributaries of trout-production Trout Brook and trout-maintenance Lamington River; Tanners Brook is non-trout waters. The species identified in these water bodies are either too small to be considered consumable or not commonly fished by the population; however, this pathway is evaluated quantitatively.
				Sediment	Sediment	Ingestion	None	Minimal contact with sediment is expected, given site use and conditions. Any exceedances of screening levels are minimal; there are only exceedances of NJDEP RDCSRS for arsenic at 20 mg/kg max conc vs. 19 mg/kg SRS and for benzo(a)pyrene at 0.34 mg/kg max conc vs. 0.2 mg/kg RDCSRS. The site is less accessible and attractive than other recreational areas in the vicinity; use by recreators and exposure in OU2 would be low. This pathway is not evaluated.
						Dermal		
			Child	Groundwater	Seeps/Springs	Ingestion	None	Recreational users may come into contact with seeps and springs that are present along Schoolhouse Lane. No water data was collected from these sources, actual groundwater data is evaluated, and exposure to seeps/springs is considered *de minimis* ; therefore, this pathway will not be evaluated. Resident exposure to deep groundwater as tapwater is expected to be protective of a recreational exposure to deep groundwater expressed as seeps/springs.
						Dermal		
				Surface Water	Surface Water	Ingestion	Quantitative	Recreational users may come into contact with surface water while visiting Trout Brook, the Lamington River UNT and Tanners Brook UNT.
						Dermal		
					Fish	Ingestion		Recreational users may ingest fish in nearby tributaries of trout-production Trout Brook and trout-maintenance Lamington River; Tanners Brook is non-trout waters. The species identified in these water bodies are either too small to be considered consumable or not commonly fished by the population; however, this pathway is evaluated quantitatively.
				Sediment	Sediment	Ingestion	None	Minimal contact with sediment is expected, given site use and conditions. Any exceedances of screening levels are minimal; there are only exceedances of NJDEP RDCSRS for arsenic at 20 mg/kg max conc vs. 19 mg/kg SRS and for benzo(a)pyrene at 0.34 mg/kg max conc vs. 0.2 mg/kg RDCSRS. The site is less accessible and attractive than other recreational areas in the vicinity; use by recreators and exposure in OU2 would be low. This pathway is not evaluated.
						Dermal		

TABLE 1
SELECTION OF EXPOSURE PATHWAYS
COMBE FILL SOUTH LANDFILL SITE OPERABLE UNIT 2
CHESTER AND WASHINGTON TOWNSHIPS, NJ

Scenario Timeframe	Source	Receptor Population	Receptor Age	Medium / Exposure Medium	Exposure Point	Exposure Route	Type of Evaluation	Rationale for Selection or Exclusion of Exposure Pathway
Current/Future	Combe Landfill Leachate Treatment Plant	Recreational User	Adult	Groundwater	Seeps/Springs	Ingestion	None	Recreational users may come into contact with seeps and springs that are present along Schoolhouse Lane. No water data was collected from these sources, actual groundwater data is evaluated, and exposure to seeps/springs is considered *de minimis*; therefore, this pathway is not evaluated. Resident exposure to deep groundwater as tapwater is expected to be protective of a recreational exposure to deep groundwater expressed as seeps/springs.
						Dermal		
				Surface Water	Surface Water	Ingestion	Quantitative	Recreational users may come into contact with surface water while visiting East Trout Brook.
						Dermal		
					Fish	Ingestion		Recreational users may ingest fish in nearby trout-production East Trout Brook. The species identified in these water bodies are either too small to be considered consumable or not commonly fished by the population; however, this pathway is evaluated quantitatively.
				Sediment	Sediment	Ingestion	None	Minimal contact with sediment is expected, given site use and conditions. None of the NJDEP RDCSRS are exceeded. In addition, any exceedances of EPA Regional Screening Levels (RSL) are minimal (benzo(a)pyrene at 0.1 mg/kg vs. 0.015 mg/kg RSL and cobalt at 4.8 mg/kg vs. 2.3 mg/kg RSL). The site is less accessible and attractive than other recreational areas in the vicinity; use by recreators and exposure in OU2 would be low. This pathway is not evaluated.
						Dermal		
			Child	Groundwater	Seeps/Springs	Ingestion	None	Recreational users may come into contact with seeps and springs that are present along Schoolhouse Lane. No water data was collected from these sources, actual groundwater data is evaluated, and exposure to seeps/springs is considered *de minimis*; therefore, this pathway is not evaluated. Resident exposure to deep groundwater as tapwater is expected to be protective of a recreational exposure to deep groundwater expressed as seeps/springs.
						Dermal		
				Surface Water	Surface Water	Ingestion	Quantitative	Recreational users may come into contact with surface water while visiting East Trout Brook.
						Dermal		
					Fish	Ingestion		Recreational users may ingest fish in nearby trout-production East Trout Brook. The species identified in these water bodies are either too small to be considered consumable or not commonly fished by the population; however, this pathway is evaluated quantitatively.
				Sediment	Sediment	Ingestion	None	Minimal contact with sediment is expected, given site use and conditions. None of the NJDEP RDCSRS are exceeded. In addition, any exceedances of EPA Regional Screening Levels (RSL) are minimal (benzo(a)pyrene at 0.1 mg/kg vs. 0.015 mg/kg RSL and cobalt at 4.8 mg/kg vs. 2.3 mg/kg RSL). The site is less accessible and attractive than other recreational areas in the vicinity; use by recreators and exposure in OU2 would be low. This pathway is not evaluated.
						Dermal		

Notes:

The evaluation of surface water includes data collected from Trout Brook, East Trout Brook, a Lamington River unnamed tributary (UNT) and a Tanners Brook UNT. East Trout Brook data will represent potential impacts downstream of permitted discharge from the Combe Landfill Leachate Treatment Plant.

Combe Fill South Landfill Site OU2 is an evaluation of groundwater in the deep aquifer, but since there is flow from groundwater to surface water, surface water will also be considered for evaluation in the BHHRA.

References:

NJDEP. 2011. Surface Water Quality Standards. N.J.A.C. 7:9B. April 4. Available online: http://www.nj.gov/dep/rules/rules/njac7_9b.pdf

NJDEP. 2005. Coldwater Fisheries Management Plan: Classification of NJ Trout Waters. Division of Fish and Wildlife. December. Available online: http://www.state.nj.us/dep/fgw/pdf/cwfmp/cwfmp-full.pdf

TABLE 2.1
OCCURRENCE, DISTRIBUTION, AND SELECTION OF COPCS FOR SITE-WIDE GROUNDWATER
COMBE FILL SOUTH LANDFILL SITE OPERABLE UNIT 2
CHESTER AND WASHINGTON TOWNSHIPS, NJ

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Site-wide Groundwater

Exposure Point	T or D	Constituent Group	Constituent	CASRN	Minimum Detected Concentration (ug/L)	Qual	Maximum Detected Concentration (ug/L)	Qual	Location of Maximum Detected Concentration	Sample Count	Detection Frequency (Ratio)	Detection Frequency (%)	Range of Detection Limits	Concentration used for Screening (ug/L) (1)	NJDEP GWQS (ug/L) (2)	EPA RSL Resident Tapwater (ug/L) (3) Value	EPA RSL Resident Tapwater (ug/L) (3) Basis	COPC Flag (Y/N)	Rationale for Selection or Deletion
Groundwater	T	VOC	1,1-dichloroethane	75-34-3	0.1	J	1.7	J	CF207D	98	38 / 98	39	0.5 - 0.50	1.7	50	2.8	c	N	Below screening level.
Groundwater	T	VOC	1,1-dichloroethene	75-35-4	0.091	J	0.17	J	CF222D	87	11 / 87	13	0.5 - 0.50	0.17	1	28	n	N	Below screening level.
Groundwater	T	VOC	1,2,3-trichlorobenzene	87-61-6	0.29	J	0.29	J	CF228D	87	1 / 87	1	0.5 - 0.50	0.29	NC	0.7	n	N	Detection frequency less than 5%.
Groundwater	T	VOC	1,2,4-trichlorobenzene	120-82-1	0.25	J	0.25	J	CF201D	88	2 / 88	2	0.5 - 0.50	0.25	9	0.4	n	N	Detection frequency less than 5%.
Groundwater	T	VOC	1,2-dichlorobenzene	95-50-1	0.11	J	0.48	J	CF207D	90	10 / 90	11	0.5 - 0.50	0.48	600	30	n	N	Below screening level.
Groundwater	T	VOC	1,2-dichloroethane	107-06-2	0.18	J	2.8	J	CF207D	104	38 / 104	37	0.5 - 0.50	2.8	2	0.17	c**	Y	Above screening level.
Groundwater	T	VOC	1,2-dichloropropane	78-87-5	0.11	J	0.87	J	CF207D	88	4 / 88	5	0.5 - 0.50	0.87	1	0.44	c**	Y	Above screening level.
Groundwater	T	VOC	1,3-dichloropropene, cis	10061-01-5	0.31	J	0.31	J	CF212D	88	1 / 88	1	0.5 - 0.50	0.31	1	NC	-	N	Detection frequency less than 5%.
Groundwater	T	VOC	1,4-dichlorobenzene	106-46-7	0.095	J	2.6	J	CF207D	94	32 / 94	34	0.5 - 0.50	2.6	75	0.48	c	Y	Above screening level.
Groundwater	T	VOC	1,4-dioxane	123-91-1	0.44	J	290	J	CF209D	110	95 / 110	86	0.5 - 0.50	290	0.4	0.46	c*	Y	Above screening level.
Groundwater	T	VOC	Acetone	67-64-1	2.3	J	200	J	CF225D	100	26 / 100	26	5 - 5.0	200	6000	1400	n	N	Below screening level.
Groundwater	T	VOC	Benzene	71-43-2	0.1	J	90	J	CF207D	102	37 / 102	36	0.5 - 0.50	90	1	0.46	c**	Y	Above screening level.
Groundwater	T	VOC	Bromochloromethane	74-97-5	0.17	J	0.29	J	CF204D	87	2 / 87	2	0.5 - 0.50	0.29	NC	8.3	n	N	Detection frequency less than 5%.
Groundwater	T	VOC	Carbon Disulfide	75-15-0	0.14	J	13	J	CF207D	93	8 / 93	9	0.5 - 0.50	13	700	81	n	N	Below screening level.
Groundwater	T	VOC	Chlorobenzene	108-90-7	0.064	J	4.4		CF222D	96	27 / 96	28	0.5 - 0.50	4.4	50	7.8	n	N	Below screening level.
Groundwater	T	VOC	Chloroethane	75-00-3	0.4	J	0.4	J	CF218D	87	1 / 87	1	0.5 - 0.50	0.4	5	2100	n	N	Detection frequency less than 5%.
Groundwater	T	VOC	Chloroform	67-66-3	0.12	J	9.2	J	CF212D	91	13 / 91	14	0.5 - 0.50	9.2	70	0.22	c*	Y	Above screening level.
Groundwater	T	VOC	Chloromethane	74-87-3	0.17	J	0.17	J	CF207D	87	1 / 87	1	0.5 - 0.50	0.17	NC	19	n	N	Detection frequency less than 5%.
Groundwater	T	VOC	Cis-1,2-dichloroethylene	156-59-2	0.11	J	6	J	CF207D	104	69 / 104	66	0.5 - 0.50	6	70	3.6	n	Y	Above screening level.
Groundwater	T	VOC	Dichlorodifluoromethane	75-71-8	0.12	J	11	J	CF207D	103	48 / 103	47	0.5 - 0.50	11	1000	20	n	N	Below screening level.
Groundwater	T	VOC	Diethyl Ether (Ethyl Ether)	60-29-7	1.1	J	620	J	CF207D	119	79 / 119	66	50 - 50	620	1000	390	n	Y	Above screening level.
Groundwater	T	VOC	Methyl Acetate	79-20-9	0.34	J	0.82		CF207D	87	2 / 87	2	0.5 - 0.50	0.82	7000	2000	n	N	Detection frequency less than 5%.
Groundwater	T	VOC	Methyl Ethyl Ketone (2-butanone)	78-93-3	5	J	22		CF209D	87	4 / 87	5	5 - 5.0	22	300	560	n	N	Below screening level.
Groundwater	T	VOC	Methylene Chloride	75-09-2	0.1	J	0.24	J	CF211D	102	3 / 102	3	0.5 - 0.50	0.24	3	11	n	N	Detection frequency less than 5%.
Groundwater	T	VOC	Tert-butyl Alcohol	75-65-0	6.1	J	92		CF218D	78	21 / 78	27	10 - 10	92	100	NC	-	N	Below screening level.
Groundwater	T	VOC	Tert-butyl Methyl Ether	1634-04-4	0.19	J	0.26	J	CF218D	88	3 / 88	3	0.5 - 0.50	0.26	70	14	c*	N	Detection frequency less than 5%.
Groundwater	T	VOC	Tetrachloroethylene (PCE)	127-18-4	0.12	J	2	J	CF207D	90	20 / 90	22	0.5 - 0.50	2	1	4.1	n	Y	Above screening level.
Groundwater	T	VOC	Toluene	108-88-3	0.067	J	35		CF209D	110	58 / 110	53	0.5 - 0.50	35	600	110	n	N	Below screening level.
Groundwater	T	VOC	Trans-1,2-dichloroethene	156-60-5	0.37	J	0.37	J	CF207D	88	1 / 88	1	0.5 - 0.50	0.37	100	36	n	N	Detection frequency less than 5%.
Groundwater	T	VOC	Trichloroethylene (TCE)	79-01-6	0.075	J	4	J	CF211D	98	55 / 98	56	0.5 - 0.50	4	1	0.28	n	Y	Above screening level.
Groundwater	T	VOC	Trichlorofluoromethane	75-69-4	0.42	J	6.5		CF212D	90	4 / 90	4	0.5 - 0.50	6.5	2000	520	n	N	Detection frequency less than 5%.
Groundwater	T	VOC	Vinyl Chloride	75-01-4	0.18	J	0.24	J	CF222D	87	3 / 87	3	0.5 - 0.50	0.24	1	0.019	c	N	Detection frequency less than 5%.
Groundwater	T	VOC	Xylene, o-	95-47-6	0.21	J	0.21	J	CF224D	87	1 / 87	1	0.5 - 0.50	0.21	1000	19	n	N	Detection frequency less than 5%.
Groundwater	T	SVOC	4-methylphenol (p-cresol)	106-44-5	1.1	J	1.1	J	CF228D	110	1 / 110	1	5 - 5.0	1.1	50	190	n	N	Detection frequency less than 5%.
Groundwater	T	SVOC	Acetophenone	98-86-2	2.3	J	2.3	J	CF201D	110	1 / 110	1	5 - 5.0	2.3	700	190	n	N	Detection frequency less than 5%.
Groundwater	T	SVOC	Benzyl Butyl Phthalate	85-68-7	1.2	J	1.2	J	CF227D	110	1 / 110	1	5 - 5.0	1.2	100	16	c*	N	Detection frequency less than 5%.
Groundwater	T	SVOC	Bis(2-ethylhexyl) Phthalate	117-81-7	2	J	15		CF206D	110	17 / 110	15	5 - 5.0	15	3	5.6	c**	Y	Above screening level.
Groundwater	T	SVOC	Caprolactam	105-60-2	2	J	1100		CF224D	110	22 / 110	20	5 - 5.0	1100	5000	990	n	Y	Above screening level.
Groundwater	T	SVOC	Diethyl Phthalate	84-66-2	3.5	J	3.5	J	CF205D	110	1 / 110	1	5 - 5.0	3.5	6000	1500	n	N	Detection frequency less than 5%.
Groundwater	T	SVOC	Di-n-butyl Phthalate	84-74-2	1.1	J	2.8	J	CF229D	110	7 / 110	6	5 - 5.0	2.8	700	90	n	N	Below screening level.
Groundwater	T	SVOC	Phenol	108-95-2	4	J	8.1		CF207D	110	2 / 110	2	5 - 5.0	8.1	2000	580	n	N	Detection frequency less than 5%.
Groundwater	T	PHYS	Cyanide	57-12-5	12		12		CF10D	109	1 / 109	1	10 - 10.0	12	100	0.15	n	N	Detection frequency less than 5%.
Groundwater	T	PEST	BHC alpha	319-84-6	0.0025	J	0.073		CF209D	109	19 / 109	17	0.005 - 0.0050	0.073	0.02	0.0072	c	Y	Above screening level.
Groundwater	T	PEST	BHC beta	319-85-7	0.0037	J	0.024	J	CF205D	110	9 / 110	8	0.005 - 0.0050	0.024	0.04	0.025	c	N	Below screening level.
Groundwater	T	PEST	BHC gamma (Lindane)	58-89-9	0.0053	J	0.0053	J	CF204D	110	1 / 110	1	0.005 - 0.0050	0.0053	0.03	0.042	c**	N	Detection frequency less than 5%.
Groundwater	T	PEST	Chlordane, alpha	5103-71-9	0.0087	NJ	0.033		CF222D	108	2 / 108	2	0.005 - 0.0050	0.033	0.5	NC	-	N	Detection frequency less than 5%.
Groundwater	T	PEST	Chlordane, gamma	5103-74-2	0.0029	J	0.0084	JN	CF216D	109	4 / 109	4	0.005 - 0.0050	0.0084	0.5	NC	-	N	Detection frequency less than 5%.
Groundwater	T	PEST	Endosulfan I (alpha)	959-98-8	0.0058	J-	0.01	J	CF227D	108	4 / 108	4	0.005 - 0.0050	0.01	40	NC	-	N	Detection frequency less than 5%.
Groundwater	T	PEST	Endrin Aldehyde	7421-93-4	0.0085	J	0.02	J	CF211D	110	6 / 110	5	0.01 - 0.010	0.02	NC	NC	-	Y	No screening level.
Groundwater	T	PEST	Heptachlor	76-44-8	0.014	J	0.021	J	CF204D	110	2 / 110	2	0.005 - 0.0050	0.021	0.05	0.0014	c*	N	Detection frequency less than 5%.
Groundwater	T	PEST	Heptachlor Epoxide	1024-57-3	0.025	NJ	0.025	NJ	CF209D	110	1 / 110	1	0.005 - 0.0050	0.025	0.2	0.0014	c**	N	Detection frequency less than 5%.
Groundwater	T	PEST	Methoxychlor	72-43-5	0.012	J	0.076	NJ	CF218D	110	13 / 110	12	0.05 - 0.050	0.076	40	3.7	n	N	Below screening level.
Groundwater	T	PEST	p,p-DDE	72-55-9	0.0052	J	0.024	J	CF211D	110	2 / 110	2	0.01 - 0.010	0.024	0.1	0.046	c	N	Detection frequency less than 5%.
Groundwater	T	PEST	p,p-DDT	50-29-3	0.017	JN	0.017	JN	CF222D	110	1 / 110	1	0.01 - 0.010	0.017	0.1	0.23	c**	N	Detection frequency less than 5%.
Groundwater	T	PCB	PCB-1260 (Aroclor 1260)	11096-82-5	0.12	J	0.2		CF204D	110	2 / 110	2	0.05 - 0.050	0.2	0.5	0.0078	c	N	Detection frequency less than 5%.
Groundwater	T	INORG	Aluminum	7429-90-5	20.7		18400		CF207D	110	16 / 110	15	20 - 200	18400	200	2000	n	Y	Above screening level.
Groundwater	T	INORG	Arsenic	7440-38-2	0.47	J	6.4	J	CF207D	110	15 / 110	14	1 - 10.0	6.4	3	0.052	c*	Y	Above screening level.
Groundwater	T	INORG	Barium	7440-39-3	2	J	2390		CF207D	110	92 / 110	84	1.0 - 200	2390	6000	380	n	Y	Above screening level.
Groundwater	T	INORG	Beryllium	7440-41-7	0.23	J	2.5	J	CF207D	110	8 / 110	7	1 - 5.0	2.5	1	2.5	n	Y	Above screening level.
Groundwater	T	INORG	Cadmium	7440-43-9	0.33	J	20.3		CF226D	110	3 / 110	3	1 - 5.0	20.3	4	0.92	n	N	Detection frequency less than 5%.
Groundwater	T	INORG	Calcium	7440-70-2	4560		125000		CF218D	110	110 / 110	100	500 - 5000	125000	NC	NC	-	N	Essential nutrient.
Groundwater	T	INORG	Chromium, Total	7440-47-3	0.53	J	262	J	CF206D	110	34 / 110	31	10.0 - 2.0	262	70	NC	-	Y	Above screening level.
Groundwater	T	INORG	Cobalt	7440-48-4	0.96	J	10.8	J	CF207D	110	15 / 110	14	1 - 50.0	10.8	100	0.6	n	Y	Above screening level.

TABLE 2.1
OCCURRENCE, DISTRIBUTION, AND SELECTION OF COPCS FOR SITE-WIDE GROUNDWATER
COMBE FILL SOUTH LANDFILL SITE OPERABLE UNIT 2
CHESTER AND WASHINGTON TOWNSHIPS, NJ

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Site-wide Groundwater

Exposure Point	T or D	Constituent Group	Constituent	CASRN	Minimum Detected Concentration (ug/L)	Qual	Maximum Detected Concentration (ug/L)	Qual	Location of Maximum Detected Concentration	Sample Count	Detection Frequency (Ratio)	Detection Frequency (%)	Range of Detection Limits	Concentration used for Screening (ug/L) (1)	NJDEP GWQS (ug/L) (2)	EPA RSL Resident Tapwater (ug/L) (3)		COPC Flag (Y/N)	Rationale for Selection or Deletion
																Value	Basis		
Groundwater	T	INORG	Copper	7440-50-8	1		1170		CF204D	109	25 / 109	23	1.0 - 25.0	1170	1300	80	n	Y	Above screening level.
Groundwater	T	INORG	Iron	7439-89-6	31.6	J	44700		WRA3-3	110	94 / 110	85	100 - 50	44700	300	1400	n	Y	Above screening level.
Groundwater	T	INORG	Lead	7439-92-1	1		175		CF207D	110	51 / 110	46	1 - 10.0	175	5	15	L	Y	Above screening level.
Groundwater	T	INORG	Magnesium	7439-95-4	193	J	32500		CF209D	110	110 / 110	100	500 - 5000	32500	NC	NC	-	N	Essential nutrient.
Groundwater	T	INORG	Manganese	7439-96-5	1.7	J	4960		CF222D	110	108 / 110	98	1 - 50	4960	50	43	n	Y	Above screening level.
Groundwater	T	INORG	Mercury	7439-97-6	0.021	J	0.36		CF207D	110	4 / 110	4	0.2 - 0.20	0.36	2	0.063	n	N	Detection frequency less than 5%.
Groundwater	T	INORG	Nickel	7440-02-0	0.44	J	149		CF207D	106	57 / 106	54	1 - 40.0	149	100	39	n	Y	Above screening level.
Groundwater	T	INORG	Potassium	7440-09-7	199	J	189000		CF224D	110	78 / 110	71	500 - 5000	189000	NC	NC	-	N	Essential nutrient.
Groundwater	T	INORG	Selenium	7782-49-2	1.5	J	7.2		CF224D	110	11 / 110	10	1.0 - 5.0	7.2	40	10	n	N	Below screening level.
Groundwater	T	INORG	Sodium	7440-23-5	3100		489000		CF10D	110	110 / 110	100	1000 - 5000	489000	50000	NC	-	Y	Above screening level.
Groundwater	T	INORG	Vanadium	7440-62-2	0.3	J	32.2	J	CF207D	110	11 / 110	10	1.0 - 50.0	32.2	NC	8.6	n	Y	Above screening level.
Groundwater	T	INORG	Zinc	7440-66-6	2.2		352		CF207D	89	67 / 89	75	2 - 60.0	352	2000	600	n	N	Below screening level.
Groundwater	T	Geochemical	Chloride (as Cl)	16887-00-6	1300		880000		CF10D	110	110 / 110	100	1000 - 840	880000	250000	NC	-	Y	Above screening level.

Notes:

(1) The maximum detected concentrations for site-wide groundwater are used for the COPC screening. Groundwater data that do not meet the requirements in the EPA memorandum titled Determining Groundwater Exposure Point Concentrations, Supplemental Guidance are excluded from the evaluation, e.g., samples collected during packer testing whose purpose was for screening only to determine well completion depths (EPA 2014, HDR 2015a and b). The remaining site-wide groundwater data are evaluated for the COPC screening.
(2) The NJDEP Groundwater Quality Standards incorporate NJ's interim standards.
(3) November 2015 USEPA Regional Screening Levels (RSLs) at a target risk of 1E-06 and target hazard quotient of 0.1 for residential exposure to tapwater.
Only unfiltered (total) groundwater data is used for COPC screening.
Constituents that RAGS Part A identifies as essential nutrients (i.e., iron, magnesium, calcium, potassium and sodium) as essential nutrients and that are present at low levels are not considered for the COPC list.
Constituents that are detected in less than 5% of the samples are not considered for the COPC list.

Abbreviations:
COPC -- Constituent of potential concern
EPA -- United States Environmental Protection Agency
INORG -- Inorganic
NC -- No criteria
NJDEP -- New Jersey Department of Environmental Protection
Qual -- Qualifier
PEST -- Pesticide
RSL -- EPA Regional Screening Levels
SVOC -- Semi-volatile organic compound
T or D -- Total or dissolved
ug/L -- Micrograms per liter
VOC -- Volatile organic compound

RSL Basis:
* -- Where noncancer RSL < 100 times cancer RSL
** -- Where noncancer RSL < 10 times cancer RSL
c -- Cancer
L -- See RSL User Guide on lead
n -- Noncancer

Qualifiers:
J -- Estimated concentration
J- -- Estimated concentration biased low
NJ -- Tentative and estimated concentration

References:

EPA. 2014. Memorandum -- Determining Groundwater Exposure Point Concentrations, Supplemental Guidance. March 11. Available online: http://www2.epa.gov/risk/exposure-point-concentrations-groundwater
EPA. 2015. Regional Screening Levels Generic Tables. November. Available online: http://www.epa.gov/risk/regional-screening-levels-rsls
HDR. 2015a. "Core of Plume" Assessment for Exposure Point Concentration Calculations. Memorandum. April 6.
HDR. 2015b. Risk Assessment Points of Discussion. Memorandum. November 3.
NJDEP. 2010. Ground Water Quality Standards. N.J.A.C. 7:9C. July 22. Available online: http://www.nj.gov/dep/rules/rules/njac7_9c.pdf
NJDEP. 2015. Interim Ground Water Quality Criteria Table. N.J.A.C. 7:9C. Last Updated November 30. Available online: http://www.nj.gov/dep/wms/bears/gwqs_interim_criteria_table.htm

TABLE 2.2
OCCURRENCE, DISTRIBUTION, AND SELECTION OF COPCS FOR SURFACE WATER
COMBE FILL SOUTH LANDFILL SITE OPERABLE UNIT 2
CHESTER AND WASHINGTON TOWNSHIPS, NJ

HDR

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water

Exposure Point	T or D	Constituent Group	Constituent	CASRN	Minimum Detected Concentration (ug/L)	Qual	Maximum Detected Concentration (ug/L)	Qual	Location of Maximum Detected Concentration	Sample Count	Detect Count	Detection Frequency (Ratio)	Detection Frequency (%)	Range of Detection Limits	Concentration used for Screening (ug/L) (1)	NJDEP SWQS (ug/L)	EPA RSL Resident Tapwater (ug/L) (2)		COPC Flag (Y/N)	Rationale for Selection or Deletion
																	Value	Basis		
Surface water	T	VOC	1,2,3-trichlorobenzene	87-61-6	0.41	J	0.41	J	TBSW0003	11	1	1 / 11	9	0.50 - 0.50	0.41	NC	0.7	n	N	Below screening level.
Surface water	T	VOC	1,4-dioxane	123-91-1	0.48	J	35		TUSW0001	18	12	12 / 18	67	0.50 - 0.50	35	NC	0.46	c*	Y	Above screening level.
Surface water	T	VOC	Diethyl Ether (Ethyl Ether)	60-29-7	2.2	J	4	J	TBSW0003	11	2	2 / 11	18	50 - 50	4	NC	390	n	N	Below screening level.
Surface water	T	VOC	Trichloroethylene (TCE)	79-01-6	0.22	J	0.4	J	TBSW0001	11	2	2 / 11	18	0.50 - 0.50	0.4	1	0.28	n	Y	Above screening level.
Surface water	T	INORG	Aluminum	7429-90-5	77.8	J	2100		TUSW0003	18	12	12 / 18	67	200 - 200	2100	NC	2000	n	Y	Above screening level.
Surface water	T	INORG	Arsenic	7440-38-2	2.8	J	2.8	J	TBSW0002	18	1	1 / 18	6	10.0 - 10.0	2.8	0.017	0.052	c*	Y	Above screening level.
Surface water	T	INORG	Barium	7440-39-3	12.3	J	49.3	J	LUSW0003	18	18	18 / 18	100	200 - 200	49.3	2000	380	n	N	Below screening level.
Surface water	T	INORG	Beryllium	7440-41-7	1.1	J	1.1	J	TUSW0003	18	1	1 / 18	6	5.0 - 5.0	1.1	6	2.5	n	N	Below screening level.
Surface water	T	INORG	Cadmium	7440-43-9	0.28	J	0.28	J	TUSW0003	18	1	1 / 18	6	5.0 - 5.0	0.28	3.4	0.92	n	N	Below screening level.
Surface water	T	INORG	Calcium	7440-70-2	8150		24100		TBSW0002	18	18	18 / 18	100	5000 - 5000	24100	NC	NC	-	N	Essential nutrient.
Surface water	T	INORG	Chromium, Total	7440-47-3	0.58	J	3.7	J	TUSW0003	18	6	6 / 18	33	10.0 - 10.0	3.7	92	NC	-	N	Below screening level.
Surface water	T	INORG	Cobalt	7440-48-4	0.87	J	3.9	J	TUSW0003	18	3	3 / 18	17	50.0 - 50.0	3.9	NC	0.6	n	Y	Above screening level.
Surface water	T	INORG	Copper	7440-50-8	4.1	J	8	J	TUSW0003	18	3	3 / 18	17	25.0 - 25.0	8	1300	80	n	N	Below screening level.
Surface water	T	INORG	Iron	7439-89-6	46.2	J	5410		LUSW0003	18	18	18 / 18	100	100 - 100	5410	NC	1400	n	Y	Above screening level.
Surface water	T	INORG	Lead	7439-92-1	2	J	26.6		TUSW0003	18	10	10 / 18	56	10.0 - 10.0	26.6	5	15	L	Y	Above screening level.
Surface water	T	INORG	Magnesium	7439-95-4	2780	J	7040		TBSW0001	18	18	18 / 18	100	5000 - 5000	7040	NC	NC	-	N	Essential nutrient.
Surface water	T	INORG	Manganese	7439-96-5	20		381		TUSW0003	18	17	17 / 18	94	15.0 - 15.0	381	NC	43	n	Y	Above screening level.
Surface water	T	INORG	Nickel	7440-02-0	1.8	J	4	J	TUSW0003	18	6	6 / 18	33	40.0 - 40.0	4	500	39	n	N	Below screening level.
Surface water	T	INORG	Potassium	7440-09-7	567	J	1020	J	TBSW0002	18	7	7 / 18	39	5000 - 5000	1020	NC	NC	-	N	Essential nutrient.
Surface water	T	INORG	Sodium	7440-23-5	2350	J	18300		TBSW0002	18	18	18 / 18	100	5000 - 5000	18300	NC	NC	-	N	Essential nutrient.
Surface water	T	INORG	Vanadium	7440-62-2	5	J	9.2	J	TUSW0003	18	2	2 / 18	11	50.0 - 50.0	9.2	NC	8.6	n	Y	Above screening level.
Surface water	T	Geochemical	Chloride (as Cl)	16887-00-6	3500		41000		TBSW0001	18	18	18 / 18	100	500 - 500	41000	250000	NC	-	N	Below screening level.

Notes:
(1) The maximum detected concentrations from Trout Brook, a Lamington River unnamed tributary (UNT) and Tanners Brook UNT are used for the COPC screening.
(2) November 2015 USEPA Regional Screening Levels (RSLs) at a target risk of 1E-06 and target hazard quotient of 0.1 for residential exposure to tap water.
Only unfiltered (total) surface water data are used for COPC screening.
Constituents that RAGS Part A identifies as essential nutrients (i.e., iron, magnesium, calcium, potassium and sodium) as essential nutrients and that are present at low levels are not considered for the COPC list.

Abbreviations:
COPC -- Constituent of potential concern
INORG -- Inorganic
EPA -- United States Environmental Protection Agency
NC -- No criteria
NJDEP -- New Jersey Department of Environmental Protection
PEST -- Pesticide
Qual -- Qualifier
SWQS -- Surface water quality standard
T or D -- Total or dissolved
ug/L -- Micrograms per liter
UNT -- Unnamed tributary
VOC -- Volatile organic compound

RSL Basis:
* -- Where noncancer RSL < 100 times cancer RSL
c -- Cancer
L -- See RSL User Guide on lead
n -- Noncancer

Qualifier:
J -- Estimated concentration

References:
NJDEP. 2011. Surface Water Quality Standards. N.J.A.C. 7:9B. April 4. Available online: http://www.nj.gov/dep/rules/rules/njac7_9b.pdf
EPA. 2015. Regional Screening Levels Generic Tables. November. Available online: http://www.epa.gov/risk/regional-screening-levels-rsls

TABLE 2.3
OCCURRENCE, DISTRIBUTION, AND SELECTION OF COPCS FOR SURFACE WATER DOWNSTREAM OF THE LEACHATE TREATMENT PLANT
COMBE FILL SOUTH LANDFILL SITE OPERABLE UNIT 2
CHESTER AND WASHINGTON TOWNSHIPS, NJ

HDR

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water Downstream of Leachate Treatment Plant

Exposure Point	T or D	Constituent Group	Constituent	CASRN	Minimum Detected Concentration (ug/L)	Qual	Maximum Detected Concentration (ug/L)	Qual	Location of Maximum Detected Concentration	Sample Count	Detect Count	Detection Frequency (Ratio)	Detection Frequency (%)	Range of Detection Limits	Concentration used for Screening (ug/L) (1)	NJDEP SWQS (ug/L)	EPA RSL Resident Tapwater (ug/L) (2)		COPC Flag (Y/N)	Rationale for Selection or Deletion
																	Value	Basis		
Surface water	T	VOC	1,2,3-trichlorobenzene	87-61-6	0.25	J	0.25	J	ETSW0003	6	1	1 / 6	17	0.50 - 0.50	0.25	NC	0.7	n	N	Below screening level.
Surface water	T	VOC	1,2,4-trichlorobenzene	120-82-1	0.3	J	0.3	J	ETSW0003	6	1	1 / 6	17	0.50 - 0.50	0.3	21	0.4	n	N	Below screening level.
Surface water	T	VOC	1,4-dioxane	123-91-1	21		61		ETSW0002	6	6	6 / 6	100	0.50 - 0.50	61	NC	0.46	c*	Y	Above screening level.
Surface water	T	VOC	Acetone	67-64-1	2.7	J	2.7	J	ETSW0003	6	1	1 / 6	17	5.0 - 5.0	2.7	NC	1400	n	N	Below screening level.
Surface water	T	VOC	Dichlorodifluoromethane	75-71-8	0.16	J	0.16	J	ETSW0003	6	1	1 / 6	17	0.50 - 0.50	0.16	NC	20	n	N	Below screening level.
Surface water	T	VOC	Diethyl Ether (Ethyl Ether	60-29-7	2.5	J	2.5	J	ETSW0003	6	1	1 / 6	17	50 - 50	2.5	NC	390	n	N	Below screening level.
Surface water	T	PEST	Chlordane, alpha	5103-71-9	0.0021	J	0.0048	J	ETSW0001	6	2	2 / 6	33	0.0050 - 0.0050	0.0048	NC	NC	-	Y	No screening level.
Surface water	T	INORG	Arsenic	7440-38-2	3.6	J	3.6	J	ETSW0002	6	1	1 / 6	17	10.0 - 10.0	3.6	0.017	0.052	c*	Y	Above screening level.
Surface water	T	INORG	Barium	7440-39-3	8.3	J	15.7	J	ETSW0001	6	6	6 / 6	100	200 - 200	15.7	2000	380	n	N	Below screening level.
Surface water	T	INORG	Calcium	7440-70-2	30900		45100		ETSW0003	6	6	6 / 6	100	5000 - 5000	45100	NC	NC	-	N	Essential nutrient.
Surface water	T	INORG	Chromium, Total	7440-47-3	0.95	J	7	J	ETSW0003	6	5	5 / 6	83	10.0 - 10.0	7	92	NC	-	N	Below screening level.
Surface water	T	INORG	Copper	7440-50-8	3.5	J	3.9	J	ETSW0002	6	3	3 / 6	50	25.0 - 25.0	3.9	1300	80	n	N	Below screening level.
Surface water	T	INORG	Iron	7439-89-6	56.3	J	139		ETSW0001	6	6	6 / 6	100	100 - 100	139	NC	1400	n	N	Essential nutrient.
Surface water	T	INORG	Lead	7439-92-1	3	J	3.8	J	ETSW0002	6	5	5 / 6	83	10.0 - 10.0	3.8	5	15	L	N	Below screening level.
Surface water	T	INORG	Magnesium	7439-95-4	11200		16200		ETSW0002	6	6	6 / 6	100	5000 - 5000	16200	NC	NC	-	N	Essential nutrient.
Surface water	T	INORG	Manganese	7439-96-5	6.8	J	70.5		ETSW0001	6	6	6 / 6	100	15.0 - 15.0	70.5	NC	43	n	Y	Above screening level.
Surface water	T	INORG	Nickel	7440-02-0	1.3	J	4	J	ETSW0001	6	5	5 / 6	83	40.0 - 40.0	4	500	39	n	N	Below screening level.
Surface water	T	INORG	Potassium	7440-09-7	2500	J	3130	J	ETSW0003	6	6	6 / 6	100	5000 - 5000	3130	NC	NC	-	N	Essential nutrient.
Surface water	T	INORG	Silver	7440-22-4	0.46	J	0.54	J	ETSW0002	6	2	2 / 6	33	10.0 - 10.0	0.54	170	9.4	n	N	Below screening level.
Surface water	T	INORG	Sodium	7440-23-5	62200		134000		ETSW0002	6	6	6 / 6	100	5000 - 5000	134000	NC	NC	-	N	Essential nutrient.
Surface water	T	Geochemical	Chloride (as Cl)	16887-00-6	27000		48000		ETSW0001	6	6	6 / 6	100	500 - 500	48000	250000	NC	-	N	Below screening level.

Notes:
(1) The maximum detected concentrations of East Trout Brook are used for the COPC screening to evaluate impacts downstream of permitted discharge from the Leachate Treatment Plant.
(2) November 2015 USEPA Regional Screening Levels (RSLs) at a target risk of 1E-06 and target hazard quotient of 0.1 for residential exposure to tapwater.
Only unfiltered (total) surface water data are used for COPC screening.
Constituents that RAGS Part A identifies as essential nutrients (i.e., iron, magnesium, calcium, potassium and sodium) as essential nutrients and that are present at low levels are not considered for the COPC list.

Abbreviations:
COPC -- Constituent of potential concern
EPA -- United States Environmental Protection Agency
INORG -- Inorganic
NC -- No criteria
NJDEP -- New Jersey Department of Environmental Protection
Qual -- Qualifier
RSL -- EPA Regional Screening Levels
SWQS -- Surface water quality standard
T or D -- Total or dissolved
ug/L -- Micrograms per liter
VOC -- Volatile organic compound

RSL Basis:
* -- Where noncancer RSL < 100 times cancer RSL
c -- Cancer
L -- See RSL User Guide on lead
n -- Noncancer

Qualifiers:
D -- Diluted concentration
J -- Estimated concentration

References:
NJDEP. 2011. Surface Water Quality Standards. N.J.A.C. 7:9B. April 4. Available online: http://www.nj.gov/dep/rules/rules/njac7_9b.pdf
EPA. 2015. Regional Screening Levels Generic Tables. November. Available online: http://www.epa.gov/risk/regional-screening-levels-rsls

TABLE 2.SUPP.1
SUMMARY OF HUMAN HEALTH COPCS
COMBE FILL SOUTH LANDFILL SITE OPERABLE UNIT 2
CHESTER AND WASHINGTON TOWNSHIPS, NJ

Constituent Group	Constituent	CASRN	Site-wide Groundwater	Surface Water	Surface Water Downstream of the Leachate Treatment Plant
VOC	1,2-dichloroethane	107-06-2	x		
VOC	1,2-dichloropropane	78-87-5	x		
VOC	1,4-dichlorobenzene	106-46-7	x		
VOC	1,4-dioxane	123-91-1	x	x	x
VOC	Benzene	71-43-2	x		
VOC	Chloroform	67-66-3	x		
VOC	Cis-1,2-dichloroethylene	156-59-2	x		
VOC	Diethyl Ether (Ethyl Ether)	60-29-7	x		
VOC	Tetrachloroethylene (PCE)	127-18-4	x		
VOC	Trichloroethylene (TCE)	79-01-6	x	x	
SVOC	Bis(2-ethylhexyl) Phthalate	117-81-7	x		
SVOC	Caprolactam	105-60-2	x		
PEST	BHC alpha	319-84-6	x		
PEST	Chlordane, alpha	5103-71-9			x
PEST	Endrin Aldehyde	7421-93-4	x		
INORG	Aluminum	7429-90-5	x	x	
INORG	Arsenic	7440-38-2	x	x	x
INORG	Barium	7440-39-3	x		
INORG	Beryllium	7440-41-7	x		
INORG	Chromium, Total	7440-47-3	x		
INORG	Cobalt	7440-48-4	x	x	
INORG	Copper	7440-50-8	x		
INORG	Iron	7439-89-6	x	x	
INORG	Lead	7439-92-1	x	x	
INORG	Manganese	7439-96-5	x	x	x
INORG	Nickel	7440-02-0	x		
INORG	Sodium	7440-23-5	x		
INORG	Vanadium	7440-62-2	x	x	
Geochemical	Chloride (as Cl)	16887-00-6	x		

Abbreviations:
INORG -- Inorganic
PEST -- Pesticide
SVOC -- Semi-volatile organic compound
VOC -- Volatile organic compound

TABLE 4.1
VALUES USED FOR DAILY INTAKE CALCULATIONS FOR GROUNDWATER
REASONABLE MAXIMUM EXPOSURE
COMBE FILL SOUTH LANDFILL SITE OPERABLE UNIT 2
CHESTER AND WASHINGTON TOWNSHIPS, NJ

HDR

Scenario Timeframe:	Current / Future
Medium:	Groundwater
Exposure Medium:	Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale / Reference	Intake Equation / Model Name
Ingestion	Resident	Adult	Tap Water	AT	Averaging Time-cancer	25550	days	EPA 2011	For noncancer, Intake (mg/kg-day) = (CW x IR x CF x EF x ED) / (BW x AT) For cancer, the ingestion rate was calculated for an adult (birth - 26 yrs), adjusting for age-specific exposure factors, where IR-Adj = ∑ (ED * IR) / BW. Intake (mg/kg-day) = (CW x (IR-Adj-adult + IR-Adj-child) x CF x EF) / AT For MMOA cancer, the IR-Adj was weighted for each age bin using ADAFs, where 0-<2 yrs applied an ADAF of 10, 2-<6 yrs applied an ADAF of 3, 6-<16 yrs applied an ADAF of 3, and 6-26 yrs applied and ADAF of 1. For TCE cancer, the intake (mg/kg-day) = (CW x [CAF x (IR-Adj-adult + IR-Adj-child) + MAF x (IR-Adj-0-2 + IR-Adj-2-6 + IR-Adj-6-16 + IR-Adj-16-26)] x EF x CF) / AT. Blood lead in children will be evaluated using the EPA Integrated Exposure Uptake Biokinetic (IEUBK) Model.
				AT	Averaging Time-noncancer	7300	days	EPA 2011	
				BW	Body Weight	80	kg	EPA 2014	
				CF	Conversion Factor	0.001	mg/µg	--	
				CW	Chemical Concentration in Water	EPC	µg/L	Calculated - Table 3.1	
				ED	Exposure Duration	20	years	EPA 2014	
				EF	Exposure Frequency	350	days/yr	EPA 2011	
				IR	Ingestion Rate	2.5	L/day	EPA 2014	
				IR-Adj-adult	Ingestion Rate Age-Adjusted	0.7	L-yr/day-kg	Calculated - Table 4.Supp.1	
				IR-Adj-6-16	Ingestion Rate Age-Adjusted MMOA 6-<16	1.1	L-yr/day-kg	Calculated - Table 4.Supp.2	
				IR-Adj-16-26	Ingestion Rate Age-Adjusted MMOA 16-<26	0.3	L-yr/day-kg	Calculated - Table 4.Supp.2	
				CAFo	TCE Cancer Adjustment Factor-oral	0.804	unitless	USEPA RSL Equations	
				MAFo	TCE Mutagen Adjustment Factor-oral	0.202	unitless	USEPA RSL Equations	
		Child	Tap Water	AT	Averaging Time-cancer	25550	days	EPA 2011	
				AT	Averaging Time-noncancer	2160	days	EPA 2011	
				BW	Body Weight	15	kg	EPA 2014	
				CF	Conversion Factor	0.001	mg/µg	--	
				CW	Chemical Concentration in Water	EPC	µg/L	Calculated - Table 3.1	
				ED	Exposure Duration	6	years	EPA 2014	
				EF	Exposure Frequency	350	days/yr	EPA 2011	
				IR	Ingestion Rate	0.78	L/day	EPA 2014	
				IR-Adj-child	Ingestion Rate Age-Adjusted	0.42	L-yr/day-kg	Calculated - Table 4.Supp.1	
				IR-Adj-0-2	Ingestion Rate Age-Adjusted MMOA 0-<2	2.06	L-yr/day-kg	Calculated - Table 4.Supp.2	
				IR-Adj-2-6	Ingestion Rate Age-Adjusted MMOA 2-<6	0.65	L-yr/day-kg	Calculated - Table 4.Supp.2	
Dermal	Resident	Adult	Tap Water	AT	Averaging Time-cancer	25550	days	EPA 2011	For noncancer, Dermally Absorbed Dose (DAD) (mg/kg-day) = (DAevent x EV x SA x EF x ED) / (BW x AT) where for organic compounds, DAevent (mg/cm2-event) = 2 FA x Kp x CW x CF x SQRT{(6 x tau-event x t-event)/pi} or DAevent = FA x Kp x CW x {(t-event/(1 + B)) + 2 x tau-event ((1 + (3 x B) + (3 x B x B)) / (1 + B)^2)} where for inorganic compounds, DAevent (mg/cm2-event) = Kp x CW x tevent x 0.001 mg/ug x 0.001 l/cm3 For cancer, the DAD was calculated for an adult (birth - 26 yrs), adjusting for age-specific exposure factors, where SA-Adj = ∑ (ED * SA) / BW. (DAD) (mg/kg-day) = ((DAevent-adult x SA-Adj-adult + DAevent-child x SA-Adj-child) x EV x EF) / AT For MMOA cancer, the IR-Adj was weighted for each age bin using ADAFs, where 0-<2 yrs applied an ADAF of 10, 2-<6 yrs applied an ADAF of 3, 6-<16 yrs applied an ADAF of 3, and 6-26 yrs applied and ADAF of 1. For TCE cancer, the DAD (mg/kg-day) = ([CAFo x (DAevent-adult x SA-Adj-adult + DAevent-child x SA-Adj-child) + MAFo x (DAevent-adult x (SA-Adj-6-16 + SA-Adj-16-26) + DAevent-child x (SA-Adj-0-2 + SA-Adj-2-6))] x EV x EF) / AT
				AT	Averaging Time-noncancer	7300	days	EPA 2011	
				B	Ratio of permeability coefficent of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis	Chemical-specific	--	EPA 2004	
				BW	Body Weight	80	kg	EPA 2014	
				CW	Chemical Concentration in Water	EPC	µg/L	Calculated - Table 3.1	
				DAevent-adult	Dermally Absorbed Dose per Event	Calculated	mg/cm2-event	Calculated - Table 4.Supp.3	
				t-event	Event Time	0.71	hr/event	EPA 2014	
				EV	Event Frequency	1	events/day	EPA 2004	
				EF	Exposure Frequency	350	days/year	EPA 2011	
				ED	Exposure Duration	20	years	EPA 2014	
				FA	Fraction Absorbed Water	Chemical-specific	--	EPA 2004	
				Kp	Permeability Constant	Chemical-specific	cm/hr	EPA 2004	
				SA	Skin Surface Area Available for Contact	19652	cm2	EPA 2014 - See Notes	
				SA-Adj-adult	Skin Surface Area Age-Adjusted	5508	cm2-yr/kg	Calculated - Table 4.Supp.1	
				SA-Adj-6-16	Skin Surface Area Age-Adjusted MMOA 6-<16	9293	cm2-yr/kg	Calculated - Table 4.Supp.2	
				SA-Adj-16-26	Skin Surface Area Age-Adjusted MMOA 16-<26	2410	cm2-yr/kg	Calculated - Table 4.Supp.2	
				tau-event	Lag time per event	Chemical-specific	hr/event	EPA 2004	
				CAFo	TCE Cancer Adjustment Factor-oral	0.804	unitless	USEPA RSL Equations	
				MAFo	TCE Mutagen Adjustment Factor-oral	0.202	unitless	USEPA RSL Equations	
		Child	Tap Water	AT	Averaging Time-cancer	25550	days	EPA 2011	
				AT	Averaging Time-noncancer	7300	days	EPA 2011	
				B	Ratio of permeability coefficent of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis	Chemical-specific	--	EPA 2004	
				BW	Body Weight	15	kg	EPA 2014	
				CW	Chemical Concentration in Water	EPC	µg/L	Calculated - Table 3.1	
				DAevent-child	Dermally Absorbed Dose per Event	Calculated	mg/cm2-event	Calculated - Table 4.Supp.3	
				t-event	Event Time	0.54	hr/event	EPA 2014	
				EV	Event Frequency	1	events/day	EPA 2004	
				EF	Exposure Frequency	350	days/year	EPA 2011	
				ED	Exposure Duration	6	years	EPA 2014	
				FA	Fraction Absorbed Water	Chemical-specific	--	EPA 2004	
				Kp	Permeability Constant	Chemical-specific	cm/hr	EPA 2004	
				SA	Skin Surface Area Available for Contact	6365	cm2	EPA 2014 - See Notes	
				SA-Adj-child	Skin Surface Area Age-Adjusted	2649	cm2-yr/kg	Calculated - Table 4.Supp.1	
				SA-Adj-0-2	Skin Surface Area Age-Adjusted MMOA 0-<2	9814	cm2-yr/kg	Calculated - Table 4.Supp.2	
				SA-Adj-2-6	Skin Surface Area Age-Adjusted MMOA 2-<6	5004	cm2-yr/kg	Calculated - Table 4.Supp.2	
				tau-event	Lag time per event	Chemical-specific	hr/event	EPA 2004	

TABLE 4.1
VALUES USED FOR DAILY INTAKE CALCULATIONS FOR GROUNDWATER
REASONABLE MAXIMUM EXPOSURE
COMBE FILL SOUTH LANDFILL SITE OPERABLE UNIT 2
CHESTER AND WASHINGTON TOWNSHIPS, NJ

HDR

Scenario Timeframe:	Current / Future
Medium:	Groundwater
Exposure Medium:	Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale / Reference	Intake Equation / Model Name
Inhalation	Resident	Adult	Water Vapors in Bathroom Air	AT	Averaging Time-cancer	25550	days	EPA 2011	The Andelman shower model as modified by Schaum et al. calculates chemical concentrations in air using chemical concentrations in water; the model is applied to VOCs only. For noncancer, Exposure Concentration (EC) (mg/m3) = (CA x ET x ED x EF x CF) / AT For cancer, EC (mg/m3) = ((CA-adult x ET-adult x ED-adult + CA-child x ET-child x ED-child) x EF x CF) / AT For TCE cancer, the EC (mg/m3) = ((CA-adult x ET-adult + CA-child x ET-child) x [CAFi x ED-adj + MAF x (ED-0-2 x 10 + ED-2-6 x 3 + ED-6-16 x 3 + ED-16-26 x 1)] x EF x CF) / AT
				AT	Averaging Time-noncancer	7300	days	EPA 2011	
				CW	Chemical Concentration in Water	EPC	µg/L	Calculated - Table 3.1	
				CA	Chemical Concentration in Air from Shower	Calculated	mg/m3	Calculated - Table 4.Supp.4	
				CF	Conversion Factor	0.042	day/hr	1 day / 24 hours	
				ET	Exposure Time	0.71	hr/day	EPA 2014	
				EF	Exposure Frequency	350	days/year	EPA 2011	
				ED	Exposure Duration	20	years	EPA 2014	
				ED-adj	TCE Exposure Duration-cancer aggregate	26	years	EPA 2011	
				CAFi	TCE Cancer Adjustment Factor-inhalation	0.756	unitless	USEPA RSL Equations	
				MAFi	TCE Mutagen Adjustment Factor-inhalation	0.244	unitless	USEPA RSL Equations	
		Child	Water Vapors in Bathroom Air	AT	Averaging Time-cancer	25550	days	EPA 2011	
				AT	Averaging Time-noncancer	2190	days	EPA 2011	
				CW	Chemical Concentration in Water	EPC	µg/L	Calculated - Table 3.1	
				CA	Chemical Concentration in Air from Shower	Calculated	mg/m3	Calculated - Table 4.Supp.4	
				CF	Conversion Factor	0.042	day/hr	1 day / 24 hours	
				ET	Exposure Time	0.54	hr/day	EPA 2014	
				EF	Exposure Frequency	350	days/year	EPA 2011	
				ED	Exposure Duration	6	years	EPA 2014	

Notes:
Intake equations are derived from EPA's RSL equations and also taken from EPA's Risk Assessment Guidance for Superfund (RAGS).
The skin surface area available for contact is the weighted average of mean values for males and females combined for total surface area, which includes the head, trunk, arms, hands, legs and feet (EPA 2014).

Abbreviations:
Adj -- Adjusted to include both adult and child exposure factors
DAD -- Dermally absorbed dose
EC -- Exposure concentration
EPA -- Environmental Protection Agency
EPC -- Exposure point concentration
RSL -- USEPA Regional Screening Level
TCE -- Trichloroethene

References:
EPA. 1991. Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER Directive 9285.6-03. Available online: http://rais.ornl.gov/documents/OSWERdirective9285.6-03.pdf
EPA. 2004. Risk Assessment Guidance for Superfund (RAGS) Volume I: Human Health Evaluation Manual. Part E Supplemental Guidance for Dermal Risk Assessment. Final. USEPA/540/R/99/005. July. Available online: http://www2.epa.gov/risk/risk-assessment-guidance-superfund-rags-part-e
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EPA. 2015. Regional Screening Level (RSL) Equations. November. Available online: http://www2.epa.gov/risk/regional-screening-table

TABLE 4.2
VALUES USED FOR DAILY INTAKE CALCULATIONS FOR SURFACE WATER
REASONABLE MAXIMUM EXPOSURE
COMBE FILL SOUTH LANDFILL SITE OPERABLE UNIT 2
CHESTER AND WASHINGTON TOWNSHIPS, NJ

HDR

Scenario Timeframe:	Current / Future
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale / Reference	Intake Equation / Model Name
Incidental Ingestion	Recreational User	Adult	Surface Water	AT	Averaging Time-cancer	25550	days	EPA 2011	For noncancer, Intake (mg/kg-day) = (CW x IR x CF x EF x ED) / (BW x AT) For cancer, the ingestion rate was calculated for an adult (birth - 26 yrs), adjusting for age-specific exposure factors, where IR-Adj = ∑ (ED * IR) / BW. Intake (mg/kg-day) = (CW x (IR-Adj-adult + IR-Adj-child) x CF x EF) / AT For MMOA cancer, the IR-Adj was weighted for each age bin using ADAFs, where 0-<2 yrs applied an ADAF of 10, 2-<6 yrs applied an ADAF of 3, 6-<16 yrs applied an ADAF of 3, and 6-26 yrs applied and ADAF of 1. For TCE cancer, the intake (mg/kg-day) = (CW x [CAF x (IR-Adj-adult + IR-Adj-child) + MAF x (IR-Adj-0-2 + IR-Adj-2-6 + IR-Adj-6-16 + IR-Adj-16-26)] x CF x EF) / AT.
				AT	Averaging Time-noncancer	7300	days	EPA 2011	
				BW	Body Weight	80	kg	EPA 2014	
				CF	Conversion Factor	0.001	mg/µg	--	
				CW	Chemical Concentration in Water	EPC	µg/L	Calculated - Tables 3.2 and 3.3	
				ED	Exposure Duration	20	years	EPA 2014	
				EF	Exposure Frequency	108	days/yr	Professional judgement - see Notes	
				IR	Ingestion Rate	0.48	L/day	EPA 2011	
				IR-Adj-adult	Ingestion Rate Age-Adjusted	0.091	L-yr/day-kg	Calculated - Table 4.Supp.1	
				IR-Adj-6-16	Ingestion Rate Age-Adjusted MMOA 6-<16	0.18	L-yr/day-kg	Calculated - Table 4.Supp.2	
				IR-Adj-16-26	Ingestion Rate Age-Adjusted MMOA 16-<26	0.032	L-yr/day-kg	Calculated - Table 4.Supp.2	
				CAFo	TCE Cancer Adjustment Factor-oral	0.804	unitless	USEPA RSL Equations	
				MAFo	TCE Mutagen Adjustment Factor-oral	0.202	unitless	USEPA RSL Equations	
		Child	Surface Water	AT	Averaging Time-cancer	25550	days	EPA 2011	
				AT	Averaging Time-noncancer	2160	days	EPA 2011	
				BW	Body Weight	15	kg	EPA 2014	
				CF	Conversion Factor	0.001	mg/µg	--	
				CW	Chemical Concentration in Water	EPC	µg/L	Calculated - Tables 3.2 and 3.3	
				ED	Exposure Duration	6	years	EPA 2014	
				EF	Exposure Frequency	108	days/yr	Professional judgement - see Notes	
				IR	Ingestion Rate	1.2	L/day	EPA 2011 / EPA Region 4 2014	
				IR-Adj-child	Ingestion Rate Age-Adjusted	0.55	L-yr/day-kg	Calculated - Table 4.Supp.1	
				IR-Adj-0-2	Ingestion Rate Age-Adjusted MMOA 0-<2	2.7	L-yr/day-kg	Calculated - Table 4.Supp.2	
				IR-Adj-2-6	Ingestion Rate Age-Adjusted MMOA 2-<6	0.84	L-yr/day-kg	Calculated - Table 4.Supp.2	
Fish Ingestion	Recreational User	Adult	Fish in Surface Water	AT	Averaging Time-cancer	25550	days	EPA 2011	For noncancer, Intake (mg/kg-day) = (CW x BCF x IR x CF1 x CF2 x EF x ED) / (BW x AT) For cancer, the ingestion rate was calculated for an adult (birth - 26 yrs), adjusting for age-specific exposure factors, where IR-Adj = ∑ (ED * IR) / BW. Intake (mg/kg-day) = (CW x BCF x (IR-Adj-adult + IR-Adj-child) x CF1 x CF2 x EF) / AT For MMOA cancer, the IR-Adj was weighted for each age bin using ADAFs, where 0-<2 yrs applied an ADAF of 10, 2-<6 yrs applied an ADAF of 3, 6-<16 yrs applied an ADAF of 3, and 6-26 yrs applied and ADAF of 1. For TCE cancer, the intake (mg/kg-day) = (CW x BCF x [CAF x (IR-Adj-adult + IR-Adj-child) + MAF x (IR-Adj-0-2 + IR-Adj-2-6 + IR-Adj-6-16 + IR-Adj-16-26)] x CF1 x CF2 x EF) / AT.
				AT	Averaging Time-noncancer	7300	days	EPA 2011	
				BCF	Fish Bioconcentration Factor	Chemical-specific	L/kg	See Table 4.Supp.5	
				BW	Body Weight	80	kg	EPA 2014	
				CF1	Conversion Factor	0.001	mg/µg	--	
				CF2	Conversion Factor	0.001	kg/g	--	
				CW	Chemical Concentration in Water	EPC	µg/L	Calculated - Tables 3.2 and 3.3	
				ED	Exposure Duration	20	years	EPA 2014	
				EF	Exposure Frequency	108	days/yr	Professional judgement - see Notes	
				IR	Ingestion Rate	23.2	g/day	EPA 2016	
				IR-Adj-adult	Ingestion Rate Age-Adjusted	8.8	g-yr/day-kg	Calculated - Table 4.Supp.1	
				IR-Adj-6-16	Ingestion Rate Age-Adjusted MMOA 6-<16	17	g-yr/day-kg	Calculated - Table 4.Supp.2	
				IR-Adj-16-26	Ingestion Rate Age-Adjusted MMOA 16-<26	3.1	g-yr/day-kg	Calculated - Table 4.Supp.2	
				CAFo	TCE Cancer Adjustment Factor-oral	0.804	unitless	USEPA RSL Equations	
				MAFo	TCE Mutagen Adjustment Factor-oral	0.202	unitless	USEPA RSL Equations	
		Child	Fish in Surface Water	AT	Averaging Time-cancer	25550	days	EPA 2011	
				AT	Averaging Time-noncancer	2160	days	EPA 2011	
				BCF	Fish Bioconcentration Factor	Chemical-specific	L/kg	See Table 4.Supp.5	
				BW	Body Weight	15	kg	EPA 2014	
				CF1	Conversion Factor	0.001	mg/µg	--	
				CF2	Conversion Factor	0.001	kg/g	--	
				CW	Chemical Concentration in Water	EPC	µg/L	Calculated - Tables 3.2 and 3.3	
				ED	Exposure Duration	6	years	EPA 2014	
				EF	Exposure Frequency	108	days/yr	Professional judgement - see Notes	
				IR	Ingestion Rate	7.73	g/day	Professional judgement - see Notes	
				IR-Adj-child	Ingestion Rate Age-Adjusted	3.5	g-yr/day-kg	Calculated - Table 4.Supp.1	
				IR-Adj-0-2	Ingestion Rate Age-Adjusted MMOA 0-<2	17	g-yr/day-kg	Calculated - Table 4.Supp.2	
				IR-Adj-2-6	Ingestion Rate Age-Adjusted MMOA 2-<6	5	g-yr/day-kg	Calculated - Table 4.Supp.2	

TABLE 4.2
VALUES USED FOR DAILY INTAKE CALCULATIONS FOR SURFACE WATER
REASONABLE MAXIMUM EXPOSURE
COMBE FILL SOUTH LANDFILL SITE OPERABLE UNIT 2
CHESTER AND WASHINGTON TOWNSHIPS, NJ

Scenario Timeframe:	Current / Future
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale / Reference	Intake Equation / Model Name
Dermal	Recreational User	Adult	Surface Water	AT	Averaging Time-cancer	25550	days	EPA 2011	For noncancer, Dermally Absorbed Dose (DAD) (mg/kg-day) = (DAevent x EV x SA x EF x ED) / (BW x AT) where for organic compounds, DAevent (mg/cm2-event) = 2 FA x Kp x CW x CF x SQRT{(6 x tau-event x t-event)/pi} or DAevent = FA x Kp x CW x {(t-event/(1 + B)) + 2 x tau-event ((1 + (3 x B) + (3 x B x B)) / (1 + B)^2)} where for inorganic compounds, DAevent (mg/cm2-event) = Kp x CW x tevent x 0.001 mg/ug x 0.001 l/cm3 For cancer, the DAD was calculated for an adult (birth - 26 yrs), adjusting for age-specific exposure factors, where SA-Adj = ∑ (ED * SA) / BW. (DAD) (mg/kg-day) = ((DAevent-adult x SA-Adj-adult + DAevent-child x SA-Adj-child) x EV x EF) / AT For MMOA cancer, the IR-Adj was weighted for each age bin using ADAFs, where 0-<2 yrs applied an ADAF of 10, 2-<6 yrs applied an ADAF of 3, 6-<16 yrs applied an ADAF of 3, and 6-26 yrs applied and ADAF of 1.
				AT	Averaging Time-noncancer	7300	days	EPA 2011	
				B	Ratio of permeability coefficent of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis	Chemical-specific	–	EPA 2004	
				BW	Body Weight	80	kg	EPA 2014	
				CW	Chemical Concentration in Water	EPC	µg/L	Calculated - Tables 3.2 and 3.3	
				DAevent	Dermally Absorbed Dose per Event	Calculated	mg/cm2-event	Calculated	
				t-event	Event Time	2.6	hr/event	EPA 1989 / EPA 2011	
				EV	Event Frequency	1	events/day	EPA 2004	
				EF	Exposure Frequency	108	days/yr	Professional judgement - see Notes	
				ED	Exposure Duration	20	years	EPA 2014	
				FA	Fraction Absorbed Water	Chemical-specific	–	EPA 2004	
				Kp	Permeability Constant	Chemical-specific	cm/hr	EPA 2004	
				SA	Skin Surface Area Available for Contact	10070	cm2	EPA 2011 / see also Table 4.Supp.1	
				SA-Adj-adult	Skin Surface Area Age-Adjusted	3035	cm2-yr/kg	Calculated - Table 4.Supp.1	
				SA-Adj-6-16	Skin Surface Area Age-Adjusted MMOA 6-<16	5107	cm2-yr/kg	Calculated - Table 4.Supp.2	
				SA-Adj-16-26	Skin Surface Area Age-Adjusted MMOA 16-<26	1333	cm2-yr/kg	Calculated - Table 4.Supp.2	
				tau-event	Lag time per event	Chemical-specific	hr/event	EPA 2004	
				CAFo	TCE Cancer Adjustment Factor-oral	0.804	unitless	USEPA RSL Equations	
				MAFo	TCE Mutagen Adjustment Factor-oral	0.202	unitless	USEPA RSL Equations	
		Child	Surface Water	AT	Averaging Time-cancer	25550	days	EPA 2011	Equations continued: For TCE cancer, the DAD (mg/kg-day) = ([CAFo x (DAevent-adult x SA-Adj-adult + DAevent-child x SA-Adj-child) + MAFo x (DAevent-adult x (SA-Adj-6-16 + SA-Adj-16-26) + DAevent-child x (SA-Adj-0-2 + SA-Adj-2-6))] x EV x EF) / AT
				AT	Averaging Time-noncancer	7300	days	EPA 2011	
				B	Ratio of permeability coefficent of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis	Chemical-specific	--	EPA 2004	
				BW	Body Weight	15	kg	EPA 2014	
				CW	Chemical Concentration in Water	EPC	µg/L	Calculated - Tables 3.2 and 3.3	
				DAevent	Dermally Absorbed Dose per Event	Calculated	mg/cm2-event	Calculated - Table 4.Supp.3	
				t-event	Event Time	2.6	hr/event	EPA 1989 / EPA 2011	
				EV	Event Frequency	1	events/day	EPA 2004	
				EF	Exposure Frequency	108	days/yr	Professional judgement - see Notes	
				ED	Exposure Duration	6	years	EPA 2014	
				FA	Fraction Absorbed Water	Chemical-specific	–	EPA 2004	
				Kp	Permeability Constant	Chemical-specific	cm/hr	EPA 2004	
				SA	Skin Surface Area Available for Contact	3870	cm2	EPA 2011 / see also Table 4.Supp.1	
				SA-Adj-child	Skin Surface Area Age-Adjusted	1308	cm2-yr/kg	Calculated - Table 4.Supp.1	
				SA-Adj-0-2	Skin Surface Area Age-Adjusted MMOA 0-<2	4609	cm2-yr/kg	Calculated - Table 4.Supp.2	
				SA-Adj-2-6	Skin Surface Area Age-Adjusted MMOA 2-<6	2542	cm2-yr/kg	Calculated - Table 4.Supp.2	
				tau-event	Lag time per event	Chemical-specific	hr/event	EPA 2004	

Notes:
Intake equations are derived from EPA's RSL equations and also taken from EPA's Risk Assessment Guidance for Superfund (RAGS).
The exposure frequency assumes the recreator visits surface water bodies 5 days/week during summer (4 weeks each in June, July, Aug) and 3 days/week during spring and fall (4 weeks each in Apr, May, Sept, Oct), which is a total of 108 days/year.
A sensitivity analysis is performed for a recreator using an exposure freqency of 52 days/year, which is based on 2 days week in the summer and 1 day/week in the spring and fall.
The child's fish ingestion rate is based on one-third of an adult fish ingestion rate.
For skin surface area available for contact, the sum of mean values for the arms, hands, legs and feet are calculated for each age group and then the maximum of these values ares used as the surface area (EPA 2011, Table 7-2). Refer to Table 4.Supp.1 for more detail.

Abbreviations:
Adj -- Adjusted to include both adult and child exposure factors
DAD -- Dermally absorbed dose
EC -- Exposure concentration
EPA -- Environmental Protection Agency
EPC -- Exposure point concentration
RSL -- USEPA Regional Screening Level

References:

EPA. 1991. Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER Directive 9285.6-03. Available online: http://rais.ornl.gov/documents/OSWERdirective9285.6-03.pdf
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EPA. 2015. Regional Screening Level (RSL) Equations. November. Available online: http://www2.epa.gov/risk/regional-screening-table
EPA. 2016. EPA Response to HDR January 8, 2016 Response to EPA December 17, 2015 Comments on Draft Pathway Analysis Report. Memorandum. January 20.
EPA Region IV. 2014. Human Health Risk Assessment Supplemental Guidance. Draft Final. January. Available online: http://www2.epa.gov/risk/region-4-human-health-risk-assessment-supplemental-guidance

TABLE 4.SUPP.1
CALCULATION OF AGE-ADJUSTED EXPOSURE FACTORS FOR A RESIDENT AND RECREATIONAL USER
COMBE FILL SOUTH LANDFILL SITE OPERABLE UNIT 2
CHESTER AND WASHINGTON TOWNSHIPS, NJ

AGE	Exposure Duration	Body Weight (1)	Intake Rate: Tap Water IR-W (2)	Intake Rate: Surface Water IR-SW (3)	Intake Rate: Fish IR-F (4)	Dermal Total Surface Area: Tap Water SA (5)	Dermal Total Surface Area: Surface Water SA (6)	Age-Adjusted Exposure Factors: AGE GROUP	IR-W-Adj	IR-SW-Adj	IR-F-Adj	SA-W-Adj	SA-SW-Adj
year	years	kg	L/day	L/day	g/day	cm^2	cm^2		L-yr/day-kg	L-yr/day-kg	g-yr/day-kg	cm^2-yr/kg	cm^2-yr/kg
Birth to 1 month	0.083	4.8	0.839	1.2	7.73	2,900	1,340						
1 to <3 months	0.17	5.9	0.896	1.2	7.73	3,300	1,510						
3 to 6 < months	0.25	7.4	1.056	1.2	7.73	3,800	1,750						
6 to <12 months	0.5	9.2	1.055	1.2	7.73	4,500	2,080						
1 to < 2 yrs	1	11.4	0.837	1.2	7.73	5,300	2,540						
2 to <3 yrs	1	13.8	0.877	1.2	7.73	6,100	3,080						
3 to < 6 yrs	3	18.6	0.959	1.2	7.73	7,600	3,870	0-<6 yrs	0.42	0.55	3.5	2,649	1,308
6 to <11 yrs	5	31.8	1.316	0.24	23.2	10,800	5,860						
11 to <16 yrs	5	56.8	1.821	0.24	23.2	15,900	8,870						
16 to <18 yrs	2	71.6	1.783	0.24	23.2	18,400	10,070						
18 to ≤ 21 yrs	3	71.6	2.368	0.24	23.2	18,400	10,070						
21 to < 26 yrs	5	80	2.958	0.24	23.2	18,000	10,070	6-<26 yrs	0.7	0.091	8.8	5,508	3,035

Equations:

IR-W-Adj (L-yr/day-kg) = $\sum$ (ED * IR-W) / BW
IR-SW-Adj (L-yr/day-kg) = $\sum$ (ED * IR-SW) / BW
IR-F-Adj (g-yr/day-kg) = $\sum$ (ED * IR-F) / BW
SA-W-Adj (cm^2-yr/kg) = $\sum$ (ED * SA-W) / BW
SA-SW-Adj (cm^2-yr/kg) = $\sum$ (ED * SA-SW) / BW

Note:

EPA Risk Assessment Guidance for Superfund (RAGS) Part A recommends applying 95th or 90th percentile values for ingestion rate and exposure duration and applying the mean values for surface area and body weight (Exhibit 6-13 and Section 6.6.1).

Abbreviations:
BW -- Body weight
ED -- Exposure duration
IR-W -- Ingestion rate of tap water
IR-SW -- Ingestion rate of surface water
IR-F -- Ingestion rate of fish
SA-W -- Skin surface area for tap water
SA-SW -- Skin surface area for surface water

References:

(1) EPA. 2011. Exposure Factors Handbook. Table 8-1 - Recommended Values for Body Weight. Mean. September. Available online: http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252

(2) EPA. 2011. Exposure Factors Handbook. Table 3-1 - Recommended Values for Drinking Water Ingestion Rates. 95th Percentile. September. Available online: http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252
(3) EPA Region IV. 2014. Human Health Risk Assessment Supplemental Guidance. Draft Final. Section 4.5. January. Available online: http://www2.epa.gov/risk/region-4-human-health-risk-assessment-supplemental-guidance
(4) EPA. 2011. Exposure Factors Handbook. Table 10-66 - Mean Consumption Rates for Individuals Who Fish or Crab in the Newark Bay Area. Adult IR-F is based on average daily consumption for people that fish. Child IR-F is half of the adult's IR-F. Available online: http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252
(5) EPA. 2011. Exposure Factors Handbook. Table 7-1 - Recommended Values for Total Body Surface Area. Mean value. September. Available online: http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252
(6) EPA. 2011. Exposure Factors Handbook. Table 7-2 - Recommended Values for Surface Area of Body Parts. Sum of mean values for arms, hands, legs and feet. September. Available online: http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252

TABLE 4.SUPP.2
CALCULATION OF AGE-ADJUSTED EXPOSURE FACTORS FOR CONSTITUENTS WITH A MUTAGENIC MODE OF ACTION FOR A RESIDENT AND RECREATIONAL USER
COMBE FILL SOUTH LANDFILL SITE OPERABLE UNIT 2
CHESTER AND WASHINGTON TOWNSHIPS, NJ

AGE	Exposure Duration	Body Weight (1)	Intake Rate			Dermal Total Surface Area		Age-Adjusted Exposure Factors						
			Tap Water IR-W (2)	Surface Water IR-SW (3)	Fish IR-F (4)	Tap Water SA (5)	Surface Water SA (6)	AGE GROUP	ADAF (7)	IR-W-Adj	IR-SW-Adj	IR-F-Adj	SA-W-Adj	SA-SW-Adj
year	years	kg	L/day	L/day	g/day	cm^2	cm^2			L-yr/day-kg	L-yr/day-kg	g-yr/day-kg	cm^2-yr/kg	cm^2-yr/kg
Birth to 1 month	0.083	4.8	0.839	1.2	7.73	2,900	1,340							
1 to <3 months	0.17	5.9	0.896	1.2	7.73	3,300	1,510							
3 to 6 < months	0.25	7.4	1.056	1.2	7.73	3,800	1,750							
6 to <12 months	0.5	9.2	1.055	1.2	7.73	4,500	2,080							
1 to < 2 yrs	1	11.4	0.837	1.2	7.73	5,300	2,540	0-<2 yrs	10	2.06	2.7	17	9,814	4,609
2 to <3 yrs	1	13.8	0.877	1.2	7.73	6,100	3,080							
3 to < 6 yrs	3	18.6	0.959	1.2	7.73	7,600	3,870	2-<6 yrs	3	0.65	0.84	5	5,004	2,542
6 to <11 yrs	5	31.8	1.316	0.24	23.2	10,800	5,860							
11 to <16 yrs	5	56.8	1.821	0.24	23.2	15,900	8,870	6-<16 yrs	3	1.1	0.18	17	9,293	5,107
16 to <18 yrs	2	71.6	1.783	0.24	23.2	18,400	10,070							
18 to < 21 yrs	3	71.6	2.368	0.24	23.2	18,400	10,070							
21 to < 26 yrs	5	80	2.958	0.24	23.2	18,000	10,070	16-<26 yrs	1	0.33	0.032	3.1	2,410	1,333

Equations:

IR-W-Adj (L-yr/day-kg) = $\sum$ (ED * IR-W * ADAF) / BW
IR-SW-Adj (L-yr/day-kg) = $\sum$ (ED * IR-SW * ADAF) / BW
IR-F-Adj (g-yr/day-kg) = $\sum$ (ED * IR-F * ADAF) / BW
SA-W-Adj (cm^2-yr/kg) = $\sum$ (ED * SA-W * ADAF) / BW
SA-SW-Adj (cm^2-yr/kg) = $\sum$ (ED * SA-SW * ADAF) / BW

Note:

EPA Risk Assessment Guidance for Superfund (RAGS) Part A recommends applying 95th or 90th percentile values for ingestion rate and exposure duration and applying the mean values for surface area and body weight (Exhibit 6-13 and Section 6.6.1).

Abbreviations:

ADAF -- Age-dependent adjustment factor
BW -- Body weight
ED -- Exposure duration
IR-W -- Ingestion rate of tap water
IR-SW -- Ingestion rate of surface water
IR-F -- Ingestion rate of fish
SA-W -- Skin surface area for tap water
SA-SW -- Skin surface area for surface water

References:

(1) EPA. 2011. Exposure Factors Handbook. Table 8-1 - Recommended Values for Body Weight. Mean. September. Available online: http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252
(2) EPA. 2011. Exposure Factors Handbook. Table 3-1 - Recommended Values for Drinking Water Ingestion Rates. 95th Percentile. September. Available online: http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252
(3) EPA Region IV. 2014. Human Health Risk Assessment Supplemental Guidance. Draft Final. Section 4.5. January. Available online: http://www2.epa.gov/risk/region-4-human-health-risk-assessment-supplemental-guidance
(4) EPA. 2011. Exposure Factors Handbook. Table 10-66 - Mean Consumption Rates for Individuals Who Fish or Crab in the Newark Bay Area. Adult IR-F is based on average daily consumption for people that fish. Child IR-F is half of the adult's IR-F. Available online: http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252
(5) EPA. 2011. Exposure Factors Handbook. Table 7-1 - Recommended Values for Total Body Surface Area. Mean value. September. Available online: http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252
(6) EPA. 2011. Exposure Factors Handbook. Table 7-2 - Recommended Values for Surface Area of Body Parts. Sum of mean values for arms, hands, legs and feet. September. Available online: http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252
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TABLE 4.SUPP.3A
CALCULATION OF DA-EVENT FOR DERMAL EXPOSURE TO SITE-WIDE GROUNDWATER
COMBE FILL SOUTH LANDFILL SITE OPERABLE UNIT 2
CHESTER AND WASHINGTON TOWNSHIPS, NJ

HDR

Chemical Group	Constituent	Casm	EPC (1)	Permeability Coefficient	Ratio of Permeability Coefficients	Lag Time	Time to Reach Steady State	Fraction Absorbed	Duration of Event (t-event)		DAevent		Equation Applied	
			Cw	K_p	B	τ_{event}	t*	FA	Adult	Child	Adult	Child	Adult	Child
			ug/L	cm/hr	unitless	hr/event	hr	unitless	hr/event	hr/event	mg/cm2-event	mg/cm2-event	Eq	Eq
VOC	1,2-dichloroethane	107-06-2	1	0.0042		0.38	0.92	1	0.71	0.54	6.0E-09	5.3E-09	2	2
VOC	1,2-dichloropropane	78-87-5	1	0.0075	0.031	0.45	1.1	1	0.71	0.54	1.2E-08	1.0E-08	2	2
VOC	1,4-dichlorobenzene	106-46-7	1	0.042	0.2	0.71	1.7	1	0.71	0.54	8.2E-08	7.2E-08	2	2
VOC	1,4-dioxane	123-91-1	1	0.00033		0.33	0.8	1	0.71	0.54	4.4E-10	3.9E-10	2	2
VOC	Benzene	71-43-2	1	0.015	0.1	0.29	0.7	1	0.71	0.54	1.9E-08	1.6E-08	3	2
VOC	Chloroform	67-66-3	1	0.0068		0.5	1.19	1	0.71	0.54	1.1E-08	9.8E-09	2	2
VOC	Cis-1,2-dichloroethylene	156-59-2	1					1	0.71	0.54			3	3
VOC	Diethyl Ether (Ethyl Ether)	60-29-7	1	0.0023		0.28	0.67	1	0.71	0.54	2.9E-09	2.5E-09	3	2
VOC	Tetrachloroethylene (PCE)	127-18-4	1	0.033	0.2	0.91	2.18	1	0.71	0.54	7.3E-08	6.4E-08	2	2
VOC	Trichloroethylene (TCE)	79-01-6	1	0.012	0.1	0.58	1.39	1	0.71	0.54	2.1E-08	1.9E-08	2	2
SVOC	Bis(2-ethylhexyl) Phthalate	117-81-7	1	0.025	0.2	17	40	1	0.71	0.54	2.4E-07	2.1E-07	2	2
SVOC	Caprolactam	105-60-2	1					1	0.71	0.54			3	3
PEST	BHC alpha	319-84-6	1					1	0.71	0.54			3	3
PEST	Endrin Aldehyde	7421-93-4	1					1	0.71	0.54			3	3
INORG	Aluminum	7429-90-5	1					1	0.71	0.54			1	1
INORG	Arsenic	7440-38-2	1	0.001				1	0.71	0.54	7.1E-10	5.4E-10	1	1
INORG	Barium	7440-39-3	1	0.001				1	0.71	0.54	7.1E-10	5.4E-10	1	1
INORG	Beryllium	7440-41-7	1	0.001				1	0.71	0.54	7.1E-10	5.4E-10	1	1
INORG	Chromium, Total	7440-47-3	1	0.002				1	0.71	0.54	1.4E-09	1.1E-09	1	1
INORG	Cobalt	7440-48-4	1					1	0.71	0.54			1	1
INORG	Copper	7440-50-8	1	0.001				1	0.71	0.54	7.1E-10	5.4E-10	1	1
INORG	Iron	7439-89-6	1					1	0.71	0.54			1	1
INORG	Lead	7439-92-1	1					1	0.71	0.54			1	1
INORG	Manganese	7439-96-5	1	0.001				1	0.71	0.54	7.1E-10	5.4E-10	1	1
INORG	Nickel	7440-02-0	1	0.0002				1	0.71	0.54	1.4E-10	1.1E-10	1	1
INORG	Sodium	7440-23-5	1					1	0.71	0.54			1	1
INORG	Vanadium	7440-62-2	1	0.001				1	0.71	0.54	7.1E-10	5.4E-10	1	1
Geochemical	Chloride (as Cl)	16887-00-6	1					1	0.71	0.54			3	3

Equations:

Inorganics: DAevent (mg/cm^2-event) =

(Eq 1) DA_{event} =
Kp x CW x tevent x CF1 x CF2
where CF1 = 0.001 mg/ug and CF2 = 0.001 L/cm3

Organics: DA_{event} (mg/cm^2-event) =

(Eq 2) $t_{event} \leq t^*$: DA_{event} (mg/cm^2-event) =
$2 \times FA \times K_p \times C_w \times (\mathrm{sqrt}((6 \times \tau_{event} \times t_{event}) / (\pi))) \times CF1 \times CF2$

(Eq 3) $t_{event} > t^*$: DA_{event} (mg/cm^2-event) =
$FA \times K_p \times C_w \times (t_{event}/(1+B) + 2 \times \tau_{event} \times ((1 + 3B + 3B^2)/(1+B)^2)) \times CF1 \times CF2$

Note:

(1) The EPC is the lower of the 95% UCL and maximum detected concentration for each COPC. An EPC of 1 ug/L is input for demonstration.
Hexavalent chromium's dermal parameters are input as surrogates because chromium total does not have dermal parameters.

Abbreviations:

CF1 -- Conversion Factor 1 (0.001 mg/ug)
CF2 -- Conversion Factor 2 (0.001 L/cm^3)
Cw -- Groundwater or surface water concentration
INORG -- Inorganic
PEST -- Pesticide
SVOC -- Semi-volatile organic compound
UCL -- Upper confidence limit
VOC -- Volatile organic compound

Reference:

EPA. 2004. Risk Assessment Guidance for Superfund (RAGS) Volume I: Human Health Evaluation Manual. Part E Supplemental Guidance for Dermal Risk Assessment. Final. USEPA/540/R/99/005. July. Available online: http://www2.epa.gov/risk/risk-assessment-guidance-superfund-rags-part-e

TABLE 4.SUPP.3B
CALCULATION OF DA-EVENT FOR DERMAL EXPOSURE TO GROUNDWATER CORE OF THE PLUME
COMBE FILL SOUTH LANDFILL SITE OPERABLE UNIT 2
CHESTER AND WASHINGTON TOWNSHIPS, NJ

Chemical Group	Constituent	Casrn	EPC (1)	Permeability Coefficient	Ratio of Permeability Coefficients	Lag Time	Time to Reach Steady State	Fraction Absorbed	Duration of Event (t-event)		DAevent		Equation Applied	
			Cw	K_p	B	τ_{event}	t*	FA	Adult	Child	Adult	Child	Adult	Child
			ug/L	cm/hr	unitless	hr/event	hr	unitless	hr/event	hr/event	mg/cm2-event	mg/cm2-event	Eq	Eq
VOC	1,4-dioxane	123-91-1	1	0.00033		0.33	0.8	1	0.71	0.54	4.4E-10	3.9E-10	2	2
VOC	Benzene	71-43-2	1	0.015	0.1	0.29	0.7	1	0.71	0.54	1.9E-08	1.6E-08	3	2
VOC	Trichloroethylene (TCE)	79-01-6	1	0.012	0.1	0.58	1.39	1	0.71	0.54	2.1E-08	1.9E-08	2	2
SVOC	Bis(2-ethylhexyl) Phthalate	117-81-7	1	0.025	0.2	17	40	1	0.71	0.54	2.4E-07	2.1E-07	2	2
PEST	BHC alpha	319-84-6	1					1	0.71	0.54			3	3
INORG	Arsenic	7440-38-2	1	0.001				1	0.71	0.54	7.1E-10	5.4E-10	1	1
INORG	Chromium, Total	7440-47-3	1	0.002				1	0.71	0.54	1.4E-09	1.1E-09	1	1
INORG	Lead	7439-92-1	1					1	0.71	0.54			1	1

Equations:

Inorganics: DAevent (mg/cm^2-event) =

(Eq 1) DA_{event} =
Kp x CW x tevent x CF1 x CF2
where CF1 = 0.001 mg/ug and CF2 = 0.001 L/cm3

Organics: DA_{event} (mg/cm^2-event) =

(Eq 2) $t_{event} \le t^*$: DA_{event} (mg/cm^2-event) =
$2 \times FA \times K_p \times C_w \times (\mathrm{sqrt}((6 \times \tau_{event} \times t_{event}) / (\pi))) \times CF1 \times CF2$

(Eq 3) $t_{event} > t^*$: DA_{event} (mg/cm^2-event) =
$FA \times K_p \times C_W \times (t_{event}/(1+B) + 2 \times \tau_{event} \times ((1 + 3B + 3B^2)/(1+B)^2)) \times CF1 \times CF2$

Note:
(1) The EPC is the lower of the 95% UCL and maximum detected concentration for each COPC. An EPC of 1 ug/L is input for demonstration.
Hexavalent chromium's dermal parameters are input as surrogates because chromium total does not have dermal parameters.

Abbreviations:
CF1 -- Conversion Factor 1 (0.001 mg/ug)
CF2 -- Conversion Factor 2 (0.001 L/cm^3)
Cw -- Groundwater or surface water concentration
INORG -- Inorganic
PEST -- Pesticide
SVOC -- Semi-volatile organic compound
UCL -- Upper confidence limit
VOC -- Volatile organic compound

Reference:
EPA. 2004. Risk Assessment Guidance for Superfund (RAGS) Volume I: Human Health Evaluation Manual. Part E Supplemental Guidance for Dermal Risk Assessment. Final. USEPA/540/R/99/005. July. Available online: http://www2.epa.gov/risk/risk-assessment-guidance-superfund-rags-part-e

TABLE 4.SUPP.3C
CALCULATION OF DA-EVENT FOR DERMAL EXPOSURE TO SURFACE WATER
COMBE FILL SOUTH LANDFILL SITE OPERABLE UNIT 2
CHESTER AND WASHINGTON TOWNSHIPS, NJ

Chemical Group	Constituent	Casrn	EPC (1)	Permeability Coefficient	Ratio of Permeability Coefficients	Lag Time	Time to Reach Steady State	Fraction Absorbed	Duration of Event (t-event)		DAevent		Equation Applied	
			Cw	K_p	B	τ_{event}	t*	FA	Adult	Child	Adult	Child	Adult	Child
			ug/L	cm/hr	unitless	hr/event	hr	unitless	hr/event	hr/event	mg/cm2-event	mg/cm2-event	Eq	Eq.
VOC	1,4-dioxane	123-91-1	1	0.00033		0.33	0.8	1	2.60	2.60	1.1E-09	1.1E-09	3	3
VOC	Trichloroethylene (TCE)	79-01-6	1	0.012	0.1	0.58	1.39	1	2.60	2.60	4.4E-08	4.4E-08	3	3
INORG	Aluminum	7429-90-5	1					1	2.60	2.60			1	1
INORG	Arsenic	7440-38-2	1	0.001				1	2.60	2.60	2.6E-09	2.6E-09	1	1
INORG	Cobalt	7440-48-4	1					1	2.60	2.60			1	1
INORG	Iron	7439-89-6	1					1	2.60	2.60			1	1
INORG	Lead	7439-92-1	1					1	2.60	2.60			1	1
INORG	Manganese	7439-96-5	1	0.001				1	2.60	2.60	2.6E-09	2.6E-09	1	1
INORG	Vanadium	7440-62-2	1	0.001				1	2.60	2.60	2.6E-09	2.6E-09	1	1

Equations:

Inorganics: DAevent (mg/cm^2-event) =

(Eq 1) DA_{event} =
Kp x CW x tevent x CF1 x CF2
where CF1 = 0.001 mg/ug and CF2 = 0.001 L/cm3

Organics: DA_{event} (mg/cm^2-event) =

(Eq 2) $t_{event} \le t^*$: DA_{event} (mg/cm^2-event) =
$2 \times FA \times K_p \times C_w \times (\mathrm{sqrt}((6 \times \tau_{event} \times t_{event}) / (\pi))) \times CF1 \times CF2$

(Eq 3) $t_{event} > t^*$: DA_{event} (mg/cm^2-event) =
$FA \times K_p \times C_W \times (t_{event}/(1+B) + 2 \times \tau_{event} \times ((1 + 3B + 3B^2)/(1+B)^2)) \times CF1 \times CF2$

Note:
(1) The EPC is the lower of the 95% UCL and maximum detected concentration for each COPC. An EPC of 1 ug/L is input for demonstration.

Abbreviations:
CF1 -- Conversion Factor 1 (0.001 mg/ug)
CF2 -- Conversion Factor 2 (0.001 L/cm^3)
Cw -- Groundwater or surface water concentration
INORG -- Inorganic
PEST -- Pesticide
SVOC -- Semi-volatile organic compound
UCL -- Upper confidence limit
VOC -- Volatile organic compound

Reference:
EPA. 2004. Risk Assessment Guidance for Superfund (RAGS) Volume I: Human Health Evaluation Manual. Part E Supplemental Guidance for Dermal Risk Assessment. Final. USEPA/540/R/99/005. July. Available online: http://www2.epa.gov/risk/risk-assessment-guidance-superfund-rags-part-e

TABLE 4.SUPP.3D
CALCULATION OF DA-EVENT FOR DERMAL EXPOSURE TO SURFACE WATER DOWNSTREAM OF THE LEACHATE TREATMENT PLANT
COMBE FILL SOUTH LANDFILL SITE OPERABLE UNIT 2
CHESTER AND WASHINGTON TOWNSHIPS, NJ

Chemical Group	Constituent	Casrn	EPC (1)	Permeability Coefficient	Ratio of Permeability Coefficients	Lag Time	Time to Reach Steady State	Fraction Absorbed	Duration of Event (t-event)		DAevent		Equation Applied	
			Cw	K_p	B	τ_{event}	t*	FA	Adult	Child	Adult	Child	Adult	Child
			ug/L	cm/hr	unitless	hr/event	hr	unitless	hr/event	hr/event	mg/cm2-event	mg/cm2-event	Eq	Eq
VOC	1,4-dioxane	123-91-1	1	0.00033		0.33	0.8	1	2.60	2.60	1.1E-09	1.1E-09	3	3
PEST	Chlordane, alpha	5103-71-9	1	0.034	0.3	21	51	0.7	2.60	2.60	4.9E-07	4.9E-07	2	2
INORG	Arsenic	7440-38-2	1	0.001				1	2.60	2.60	2.6E-09	2.6E-09	1	1
INORG	Manganese	7439-96-5	1	0.001				1	2.60	2.60	2.6E-09	2.6E-09	1	1

Equations:

Inorganics: DAevent (mg/cm^2-event) =

(Eq 1) DA_{event} =
Kp x CW x tevent x CF1 x CF2
where CF1 = 0.001 mg/ug and CF2 = 0.001 L/cm3

Organics: DA_{event} (mg/cm^2-event) =

(Eq 2) $t_{event} \le t^*$: DA_{event} (mg/cm^2-event) =
$2 \times FA \times K_p \times C_w \times (\mathrm{sqrt}((6 \times \tau_{event} \times t_{event}) / (\pi))) \times CF1 \times CF2$

(Eq 3) $t_{event} > t^*$: DA_{event} (mg/cm^2-event) =
$FA \times K_p \times C_W \times (t_{event}/(1+B) + 2 \times \tau_{event} \times ((1 + 3B + 3B^2)/(1+B)^2)) \times CF1 \times CF2$

Note:
(1) The EPC is the lower of the 95% UCL and maximum detected concentration for each COPC. An EPC of 1 ug/L is input for demonstration.

Abbreviations:
CF1 -- Conversion Factor 1 (0.001 mg/ug)
CF2 -- Conversion Factor 2 (0.001 L/cm^3)
Cw -- Groundwater or surface water concentration
INORG -- Inorganic
PEST -- Pesticide
SVOC -- Semi-volatile organic compound
UCL -- Upper confidence limit
VOC -- Volatile organic compound

Reference:
EPA. 2004. Risk Assessment Guidance for Superfund (RAGS) Volume I: Human Health Evaluation Manual. Part E Supplemental Guidance for Dermal Risk Assessment. Final. USEPA/540/R/99/005. July. Available online: http://www2.epa.gov/risk/risk-assessment-guidance-superfund-rags-part-e

TABLE 4.SUPP.4A
BATHROOM AIR CONCENTRATIONS FROM EXPOSURE TO TAPWATER FOR A RESIDENT USING SITE-WIDE GROUNDWATER
COMBE FILL SOUTH LANDFILL SITE OPERABLE UNIT 2
CHESTER AND WASHINGTON TOWNSHIPS, NJ

Constituent Group	Constituent	CASRN	EPC (1)	Adult		Child	
			CW	$C_{a\text{-}max}$	C_a	C_{amax}	C_a
			mg/L	mg/m³	mg/m³	mg/m³	mg/m³
VOC	1,2-dichloroethane	107-06-2	0.001	0.038	0.031	0.050	0.034
VOC	1,2-dichloropropane	78-87-5	0.001	0.038	0.031	0.050	0.034
VOC	1,4-dichlorobenzene	106-46-7	0.001	0.038	0.031	0.050	0.034
VOC	1,4-dioxane	123-91-1	0.001	0.038	0.031	0.050	0.034
VOC	Benzene	71-43-2	0.001	0.038	0.031	0.050	0.034
VOC	Chloroform	67-66-3	0.001	0.038	0.031	0.050	0.034
VOC	Cis-1,2-dichloroethylene	156-59-2	0.001	0.038	0.031	0.050	0.034
VOC	Diethyl Ether (Ethyl Ether)	60-29-7	0.001	0.038	0.031	0.050	0.034
VOC	Tetrachloroethylene (PCE)	127-18-4	0.001	0.038	0.031	0.050	0.034
VOC	Trichloroethylene (TCE)	79-01-6	0.001	0.038	0.031	0.050	0.034

Variables	Units	Exposure Assumptions
C_a = concentration of chemical in air	mg/m³	Solved by Eq 1
C_{amax} = maximum concentration of chemical in air	mg/m³	Solved by Eq 2
t_1 = Adult time in shower	hr	0.25
t_1 = Child time in shower	hr	0.33
t_2 = Adult time in bathroom after shower	hr	0.46
t_2 = Child time in bathroom after shower	hr	0.21
f = fraction volatilized for chemical	unitless	0.9
F_w = shower water flow rate	L/hr	1000
V_a = bathroom volume	m³	6

Equation 1:	C_a =	$((C_{amax}/2) * t_1 + C_{amax} \cdot t_2) / (t_1 + t_2)$
Equation 2:	C_{amax} =	$(C_w * f * F_w * t_1) / V_a$

Note:
(1) The EPC is the lower of the 95% UCL and maximum detected concentration. An EPC of 1 ug/L is input for demonstration.

The most conservative value of the ranges for each exposure parameter, as presented in Schaum et al 1994, is applied for the calculations. The shower model air chemical concentrations are calculated for only VOCs.

Total exposure times for are 0.71 hr for an adult and 0.54 hr for a child. Professional judgement is used to split up the time spent in the shower versus in the bathroom after shower. An adult is assumed to spend approximately 15 minutes showering followed by 28 minutes in the bathroom, for a total of 43 minutes (0.71 hr). A child is assumed to spend approximately 20 minutes bathing followed by 13 minutes in the bathroom for a total of 32 minutes (0.54 hr).

Abbreviation:
CW -- Groundwater water concentration
EPC -- Exposure point concentration
INORG -- Inorganic
PEST -- Pesticide
SVOC -- Semi-volatile organic compound
VOC -- Volatile organic compound

Reference:
Wang, Rhoda G.M. et al. 1994. Water Consumption and Health: Integration of Exposure Assessment, Toxicology, and Risk Assessment. Wang. Macel Dekker, Inc., New York. Estimating Dermal and Inhalation Exposure to Volatile Chemicals in Domestic Water, Schaum et al., Pages 307-320.

TABLE 4.SUPP.4B
BATHROOM AIR CONCENTRATIONS FROM EXPOSURE TO TAPWATER FOR A RESIDENT USING GROUNDWATER CORE OF THE PLUME
COMBE FILL SOUTH LANDFILL SITE OPERABLE UNIT 2
CHESTER AND WASHINGTON TOWNSHIPS, NJ

Constituent Group	Constituent	CASRN	EPC (1)	Adult		Child	
			CW	$C_{a\text{-}max}$	C_a	C_{amax}	C_a
			mg/L	mg/m³	mg/m³	mg/m³	mg/m³
VOC	1,4-dioxane	123-91-1	0.001	0.038	0.031	0.050	0.034
VOC	Benzene	71-43-2	0.001	0.038	0.031	0.050	0.034
VOC	Trichloroethylene (TCE)	79-01-6	0.001	0.038	0.031	0.050	0.034

Variables	Units	Exposure Assumptions
C_a = concentration of chemical in air	mg/m³	Solved by Eq 1
C_{amax} = maximum concentration of chemical in air	mg/m³	Solved by Eq 2
t_1 = Adult time in shower	hr	0.25
t_1 = Child time in shower	hr	0.33
t_2 = Adult time in bathroom after shower	hr	0.46
t_2 = Child time in bathroom after shower	hr	0.21
f = fraction volatilized for chemical	unitless	0.9
F_w = shower water flow rate	L/hr	1000
V_a = bathroom volume	m³	6

Equation 1:	C_a =	$((C_{amax}/2) * t_1 + C_{amax} \cdot t_2) / (t_1 + t_2)$
Equation 2:	C_{amax} =	$(C_w * f * F_w * t_1) / V_a$

Note:
(1) The EPC is the lower of the 95% UCL and maximum detected concentration. An EPC of 1 ug/L is input for demonstration.

The most conservative value of the ranges for each exposure parameter, as presented in Schaum et al 1994, is applied for the calculations. The shower model air chemical concentrations are calculated for only VOCs.

Total exposure times for are 0.71 hr for an adult and 0.54 hr for a child. Professional judgement is used to split up the time spent in the shower versus in the bathroom after shower. An adult is assumed to spend approximately 15 minutes showering followed by 28 minutes in the bathroom, for a total of 43 minutes (0.71 hr). A child is assumed to spend approximately 20 minutes bathing followed by 13 minutes in the bathroom for a total of 32 minutes (0.54 hr).

Abbreviation:
CW -- Groundwater water concentration
EPC -- Exposure point concentration
INORG -- Inorganic
PEST -- Pesticide
SVOC -- Semi-volatile organic compound
VOC -- Volatile organic compound

Reference:
Wang, Rhoda G.M. et al. 1994. Water Consumption and Health: Integration of Exposure Assessment, Toxicology, and Risk Assessment. Wang. Macel Dekker, Inc., New York. Estimating Dermal and Inhalation Exposure to Volatile Chemicals in Domestic Water, Schaum et al., Pages 307-320.

TABLE 4.SUPP.5
BIOCONCENTRATION FACTORS
COMBE FILL SOUTH LANDFILL SITE OPERABLE UNIT 2
CHESTER AND WASHINGTON TOWNSHIPS, NJ

Constituent Group	Constituent	CASRN	Surface Water to Fish BCF (L/kg)	
			Value	Reference
VOC	1,4-dioxane	123-91-1	0.5	DOE 2015
VOC	Trichloroethylene (TCE)	79-01-6	10.6	EPA 2002
PEST	Chlordane (total)	57-74-9	14100	EPA 2002
PEST	Chlordane, alpha	5103-71-9	14100	EPA 2002
INORG	Aluminum	7429-90-5	500	DOE 2015
INORG	Arsenic	7440-38-2	44	EPA 2002
INORG	Cobalt	7440-48-4	300	DOE 2015
INORG	Iron	7439-89-6	200	DOE 2015
INORG	Lead	7439-92-1	300	DOE 2015
INORG	Manganese	7439-96-5	400	DOE 2015
INORG	Vanadium	7440-62-2	1	--

Notes:

BCFs from EPA National Recommended Water Quality Criteria basis document are applied first and then BCFs from the DOE ORNL. When no surface water to fish BCF is available, tissue concentration is assumed to be equivalent to the media concentration and a BCF value of 1 is input for vanadium.

Abbreviations:
BCF -- Bioconcentration factor
DOE -- Department of Energy
EPA -- Environmental Protection Agency

References:

DOE. 2015. Chemical Specific Parameters. Oak Ridge National Laboratory (ORNL) - The Risk Assessment Information System (RAIS). April. Click Chemical Tools - Chemical Parameters. Available online: http://rais.ornl.gov/cgi-bin/tools/TOX_search?select=chem_spef

EPA. 2002. National Recommended Water Quality Criteria – Human Health Criteria Calculation Matrix. Office of Water. November. Available online: http://water.epa.gov/scitech/swguidance/standards/upload/2002_12_30_criteria_wqctable_hh_calc_matrix.pdf

EPA. 2007. Guidance for Developing Ecological Soil Screening levels (Eco-SSLs). OSWER Directive 9285.7-55. Attachment 4-1. April. Available online: http://rais.ornl.gov/documents/ecossl_attachment_1-4.pdf

HDR

TABLE 5.1
NONCANCER TOXICITY DATA -- ORAL/DERMAL
COMBE FILL SOUTH LANDFILL SITE OPERABLE UNIT 2
CHESTER AND WASHINGTON TOWNSHIPS, NJ

Constituent Group	Constituent	CASRN	Chronic / Subchronic	Oral Reference Dose (RfD)		GIABS	Oral Absorption Efficiency for Dermal	Absorbed RfD for Dermal		Primary Target Organ(s)	Combined Uncertainty / Modifying Factors	Source	Source Date
				Value	Units			Value	Units				
VOC	1,2-dichloroethane	107-06-2	Chronic	0.006	mg/kg-day	1	100%	0.006	mg/kg-day	Kidney	10000	EPA PPRTV Appendix	10/1/2010
VOC	1,2-dichloropropane	78-87-5	Chronic	0.09	mg/kg-day	1	100%	0.09	mg/kg-day	Liver	1000	ATSDR	12/1/1989
VOC	1,4-dichlorobenzene	106-46-7	Chronic	0.07	mg/kg-day	1	100%	0.07	mg/kg-day	Liver	100	ATSDR	7/1/2006
VOC	1,4-dioxane	123-91-1	Chronic	0.03	mg/kg-day	1	100%	0.03	mg/kg-day	Liver / Kidney	300	EPA IRIS	8/11/2010
VOC	Benzene	71-43-2	Chronic	0.004	mg/kg-day	1	100%	0.004	mg/kg-day	Blood	300,1	EPA IRIS	4/17/2003
VOC	Chloroform	67-66-3	Chronic	0.01	mg/kg-day	1	100%	0.01	mg/kg-day	Liver	1000	EPA IRIS	10/19/2001
VOC	Cis-1,2-dichloroethylene	156-59-2	Chronic	0.002	mg/kg-day	1	100%	0.002	mg/kg-day	Kidney	3000	EPA IRIS	9/30/2010
VOC	Diethyl Ether (Ethyl Ether)	60-29-7	Chronic	0.2	mg/kg-day	1	100%	0.2	mg/kg-day	Body weight	3000/1	EPA IRIS	7/1/1993
VOC	Tetrachloroethylene (PCE)	127-18-4	Chronic	0.006	mg/kg-day	1	100%	0.006	mg/kg-day	Neurotoxicity	1000	EPA IRIS	2/10/2012
VOC	Trichloroethylene (TCE)	79-01-6	Chronic	0.0005	mg/kg-day	1	100%	0.0005	mg/kg-day	Multiple	100,1000,10	EPA IRIS	9/28/2011
SVOC	Bis(2-ethylhexyl) Phthalate	117-81-7	Chronic	0.02	mg/kg-day	1	100%	0.02	mg/kg-day	Liver	1000	EPA IRIS	5/1/1991
SVOC	Caprolactam	105-60-2	Chronic	0.5	mg/kg-day	1	100%	0.5	mg/kg-day	Reproductive	100, 1	EPA IRIS	9/7/1988
PEST	BHC alpha	319-84-6	Chronic	0.008	mg/kg-day	1	100%	0.008	mg/kg-day	Liver	100	ATSDR	9/1/2005
PEST	Chlordane, alpha	5103-71-9	Chronic	0.0005	mg/kg-day	1	100%	0.0005	mg/kg-day	Liver	300/1	EPA IRIS	2/7/1998
PEST	Endrin Aldehyde	7421-93-4	NA	NA	NA	1	100%	NA	NA	NA	NA	NA	NA
INORG	Aluminum	7429-90-5	Chronic	1	mg/kg-day	1	100%	1	mg/kg-day	Neurological	100	EPA PPRTV	10/23/2006
INORG	Arsenic	7440-38-2	Chronic	0.0003	mg/kg-day	1	100%	0.0003	mg/kg-day	Skin	3	EPA IRIS	2/1/1993
INORG	Barium	7440-39-3	Chronic	0.2	mg/kg-day	0.07	7%	0.014	mg/kg-day	Kidney	300	EPA IRIS	7/11/2005
INORG	Beryllium	7440-41-7	NA	NA	NA	0.007	1%	NA	NA	NA	NA	NA	NA
INORG	Chromium, Total	7440-47-3	Chronic	0.003	mg/kg-day	0.025	3%	0.000075	mg/kg-day	None indicated	300/3	EPA IRIS	9/3/1998
INORG	Cobalt	7440-48-4	Chronic	0.0003	mg/kg-day	1	100%	0.0003	mg/kg-day	Thyroid	3000	EPA PPRTV	8/25/2008
INORG	Copper	7440-50-8	Chronic	0.04	mg/kg-day	1	100%	0.04	mg/kg-day	Digestive	NA	EPA HEAST - Refer to RSLs FAQ #30 also.	1/1/1987
INORG	Iron	7439-89-6	Chronic	0.7	mg/kg-day	1	100%	0.7	mg/kg-day	Digestive	1.5	EPA PPRTV	9/11/2006
INORG	Lead	7439-92-1	NA	NA	NA	1	100%	NA	NA	NA	NA	NA	NA
INORG	Manganese	7439-96-5	Chronic	0.024	mg/kg-day	0.04	4%	0.00096	mg/kg-day	Neurological	3	EPA RSL User Guide Section 5 / EPA IRIS	5/1/1996
INORG	Nickel	7440-02-0	Chronic	0.02	mg/kg-day	0.04	4%	0.0008	mg/kg-day	Body Weight	300/1	EPA IRIS	12/1/1996
INORG	Sodium	7440-23-5	NA	NA	NA	1	100%	NA	NA	NA	NA	NA	NA
INORG	Vanadium	7440-62-2	Chronic	0.005	mg/kg-day	0.026	3%	0.00013	mg/kg-day	Loss of hair cystine	RfD of Vn Pentoxide x 56% for molecular weight of Vn	EPA RSL User Guide Section 5 / EPA IRIS	12/1/1996
Geochemical	Chloride (as Cl)	16887-00-6	NA	NA	NA	1	100%	NA	NA	NA	NA	NA	NA

Note:
The oral RfDs are taken from the November 2015 EPA Regional Screening Levels (RSLs) table, which gathers toxicity reference values from multiple sources using an established hierarchy.
The absorbed RfD for dermal is calculated by the following equation: RfD-oral x GIABS.
EPA recommends that the oral RfD should not be adjusted to estimate the absorbed dose for compounds when the absorption efficiency is greater than 50%.
The oral RfD and GIABS for cadmium (water) and manganese (non-diet) are used for hazard quotient calculations.
Since chromium total does not have toxicity values identified in the source, those of hexavalent (VI) chromium are input as surrogates.

Abbreviations:
GIABS -- Gastrointestinal absorption factor
INORG -- Inorganic
NA -- Not available
PEST -- Pesticide
RfD -- Reference dose
RSLs -- EPA Regional Screening Levels
SVOC -- Semi-volatile organic compound
VOC -- Volatile organic compound

References:
EPA. 2004. Risk Assessment Guidance for Superfund (RAGS) Volume I: Human Health Evaluation Manual. Part E Supplemental Guidance for Dermal Risk Assessment. Final. USEPA/540/R/99/005. July. Available online: http://www2.epa.gov/risk/risk-assessment-guidance-superfund-rags-part-e
EPA. 2015. Regional Screening Level (RSL) Generic Tables. June. Available online: http://www2.epa.gov/risk/regional-screening-table

Toxicity Sources:
ATSDR. 2014. Minimal Risk Levels (MRLs). December. Available online: http://www.atsdr.cdc.gov/mrls/index.asp
EPA. 2011. Health Effects Assessment Summary Tables (HEAST). December. Available online : http://epa-heast.ornl.gov/
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TABLE 5.2
NONCANCER TOXICITY DATA – INHALATION
COMBE FILL SOUTH LANDFILL SITE OPERABLE UNIT 2
CHESTER AND WASHINGTON TOWNSHIPS, NJ

Constituent Group	Constituent	CASRN	Chronic / Subchronic	Inhalation Reference Concentration (RfC)		Primary Target Organ(s)	Combined Uncertainty / Modifying Factors	Source	Source Date
				Value	Units				
VOC	1,2-dichloroethane	107-06-2	Chronic	0.007	mg/m3	Neurological	3000	EPA PPRTV	10/1/2010
VOC	1,2-dichloropropane	78-87-5	Chronic	0.004	mg/m3	Respiratory	300 / 1	EPA IRIS	12/1/1991
VOC	1,4-dichlorobenzene	106-46-7	Chronic	0.8	mg/m3	Liver	100/1	EPA IRIS	11/1/1996
VOC	1,4-dioxane	123-91-1	Chronic	0.03	mg/m3	Skin	1000	EPA IRIS	9/20/2013
VOC	Benzene	71-43-2	Chronic	0.03	mg/m3	Blood	300,1	EPA IRIS	4/17/2003
VOC	Chloroform	67-66-3	Chronic	0.098	mg/m3	Liver	100	ATSDR	9/1/1997
VOC	Cis-1,2-dichloroethylene	156-59-2	NA	NA	NA	NA	NA	NA	NA
VOC	Diethyl Ether (Ethyl Ether)	60-29-7	NA	NA	NA	NA	NA	NA	NA
VOC	Tetrachloroethylene (PCE)	127-18-4	Chronic	0.04	mg/m3	Neurotoxicity	1000	EPA IRIS	2/10/2012
VOC	Trichloroethylene (TCE)	79-01-6	Chronic	0.002	mg/m3	Multiple	100,10	EPA IRIS	9/28/2011
SVOC	Bis(2-ethylhexyl) Phthalate	117-81-7	NA	NA	NA	NA	NA	NA	NA
SVOC	Caprolactam	105-60-2	Chronic	0.0022	mg/m3	Respiratory	NA	Cal EPA	10/1/2013
PEST	BHC alpha	319-84-6	NA	NA	NA	NA	NA	NA	NA
PEST	Chlordane, alpha	5103-71-9	Chronic	0.0007	mg/m3	Liver	1000/1	EPA IRIS	2/7/1998
PEST	Endrin Aldehyde	7421-93-4	NA	NA	NA	NA	NA	NA	NA
INORG	Aluminum	7429-90-5	Chronic	0.005	mg/m3	Neurological	300	EPA PPRTV	10/23/2006
INORG	Arsenic	7440-38-2	Chronic	0.000015	mg/m3	Developmental, Reproductive, Cardiovascular	None indicated	Cal EPA	12/1/2008
INORG	Barium	7440-39-3	Chronic	0.0005	mg/m3	Fetus	1000	EPA HEAST	9/1/1984
INORG	Beryllium	7440-41-7	Chronic	0.00002	mg/m3	Respiratory	10	EPA IRIS	4/3/1998
INORG	Chromium, Total	7440-47-3	Subchronic	0.0001	mg/m3	Respiratory/Immune	300/1	EPA IRIS	9/3/1998
INORG	Cobalt	7440-48-4	Chronic	0.000006	mg/m3	Respiratory	300	EPA PPRTV	10/23/2006
INORG	Copper	7440-50-8	NA	NA	NA	NA	NA	NA	NA
INORG	Iron	7439-89-6	NA	NA	NA	NA	NA	NA	NA
INORG	Lead	7439-92-1	NA	NA	NA	NA	NA	NA	NA
INORG	Manganese	7439-96-5	Chronic	0.00005	mg/m3	Neurological	100/1	EPA IRIS	12/1/1993
INORG	Nickel	7440-02-0	Chronic	0.00009	mg/m3	Respiratory	30	ATSDR	9/1/2005
INORG	Sodium	7440-23-5	NA	NA	NA	NA	NA	NA	NA
INORG	Vanadium	7440-62-2	Chronic	0.0001	mg/m3	Respiratory	30	ATSDR	9/1/2012
Geochemical	Chloride (as Cl)	16887-00-6	NA	NA	NA	NA	NA	NA	NA

Note:
The inhalation RfCs are taken from the November 2015 EPA Regional Screening Levels (RSLs) table, which gathers toxicity reference values from multiple sources using an established hierarchy.
Since chromium total does not have toxicity values identified in the source, those of hexavalent (VI) chromium are input as surrogates.

Abbreviation:
INORG – Inorganic
NA – Not available
PEST – Pesticide
RfC – Reference concentration
RSLs – EPA Regional Screening Levels
SVOC – Semi-volatile organic compound
VOC – Volatile organic compound

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TABLE 6.1
CANCER TOXICITY DATA – ORAL/DERMAL
COMBE FILL SOUTH LANDFILL SITE OPERABLE UNIT 2
CHESTER AND WASHINGTON TOWNSHIPS, NJ

Constituent Group	Constituent	CASRN	Mutagenic	Oral Slope Factor (SFo)		GIABS	Oral Absorption Efficiency for Dermal	Absorbed SFd for Dermal		Weight of Evidence / Cancer Guidelines Description	Source	Source Date
				Value	Units			Value	Units			
VOC	1,2-dichloroethane	107-06-2	N	0.091	(mg/kg-day)-1	1	100%	0.091	(mg/kg-day)-1	B2	EPA IRIS	1/1/1991
VOC	1,2-dichloropropane	78-87-5	N	0.036	(mg/kg-day)-1	1	100%	0.036	(mg/kg-day)-1	B2 / Likely to be carcinogenic to humans	Cal EPA	2/1/1999
VOC	1,4-dichlorobenzene	106-46-7	N	0.0054	(mg/kg-day)-1	1	100%	0.0054	(mg/kg-day)-1	B2	Cal EPA	2/1/1997
VOC	1,4-dioxane	123-91-1	N	0.1	(mg/kg-day)-1	1	100%	0.1	(mg/kg-day)-1	Likely to be carcinogenic to humans	EPA IRIS	9/20/2013
VOC	Benzene	71-43-2	N	0.055	(mg/kg-day)-1	1	100%	0.055	(mg/kg-day)-1	A / Known human carcinogen	EPA IRIS	1/9/2000
VOC	Chloroform	67-66-3	N	0.031	(mg/kg-day)-1	1	100%	0.031	(mg/kg-day)-1	B2	Cal EPA	5/1/2010
VOC	Cis-1,2-dichloroethylene	156-59-2	N	NA	NA	1	100%	NA	NA	NA	NA	NA
VOC	Diethyl Ether (Ethyl Ether)	60-29-7	N	NA	NA	1	100%	NA	NA	NA	NA	NA
VOC	Tetrachloroethylene (PCE)	127-18-4	N	0.0021	(mg/kg-day)-1	1	100%	0.0021	(mg/kg-day)-1	Likely to be carcinogenic in humans	EPA IRIS	2/10/2012
VOC	Trichloroethylene (TCE)	79-01-6	Y	0.046	(mg/kg-day)-1	1	100%	0.046	(mg/kg-day)-1	Carcinogenic to humans	EPA IRIS	9/28/2011
SVOC	Bis(2-ethylhexyl) Phthalate	117-81-7	N	0.014	(mg/kg-day)-1	1	100%	0.014	(mg/kg-day)-1	B2	EPA IRIS	2/1/1993
SVOC	Caprolactam	105-60-2	N	NA	NA	1	100%	NA	NA	NA	NA	NA
PEST	BHC alpha	319-84-6	N	6.3	(mg/kg-day)-1	1	100%	6.3	(mg/kg-day)-1	B2	EPA IRIS	7/1/1993
PEST	Chlordane, alpha	5103-71-9	N	0.35	(mg/kg-day)-1	1	100%	0.35	(mg/kg-day)-1	B2	EPA IRIS	2/7/1998
PEST	Endrin Aldehyde	7421-93-4	N	NA	NA	1	100%	NA	NA	NA	NA	NA
INORG	Aluminum	7429-90-5	N	NA	NA	1	100%	NA	NA	NA	NA	NA
INORG	Arsenic	7440-38-2	N	1.5	(mg/kg-day)-1	1	100%	1.5	(mg/kg-day)-1	A	EPA IRIS	4/10/1998
INORG	Barium	7440-39-3	N	NA	NA	0.07	7%	NA	NA	NA	NA	NA
INORG	Beryllium	7440-41-7	N	NA	NA	0.007	1%	NA	NA	NA	NA	NA
INORG	Chromium, Total	7440-47-3	Y	0.5	(mg/kg-day)-1	0.025	3%	20	(mg/kg-day)-1	D / Carcinogenic potential cannot be determined	NJDEP / EPA IRIS	4/8/2009
INORG	Cobalt	7440-48-4	N	NA	NA	1	100%	NA	NA	NA	NA	NA
INORG	Copper	7440-50-8	N	NA	NA	1	100%	NA	NA	NA	NA	NA
INORG	Iron	7439-89-6	N	NA	NA	1	100%	NA	NA	NA	NA	NA
INORG	Lead	7439-92-1	N	NA	NA	1	100%	NA	NA	NA	NA	NA
INORG	Manganese	7439-96-5	N	NA	NA	0.04	4%	NA	NA	NA	NA	NA
INORG	Nickel	7440-02-0	N	NA	NA	0.04	4%	NA	NA	NA	NA	NA
INORG	Sodium	7440-23-5	N	NA	NA	1	100%	NA	NA	NA	NA	NA
INORG	Vanadium	7440-62-2	N	NA	NA	0.026	3%	NA	NA	NA	NA	NA
Geochemical	Chloride (as Cl)	16887-00-6	N	NA	NA	1	100%	NA	NA	NA	NA	NA

Note:
The oral SFs are taken from the June 2015 EPA Regional Screening Levels (RSLs) table, which gathers toxicity reference values from multiple sources using an established hierarchy.
The absorbed SFd for dermal is calculated by the following equation: SF-oral / GIABS.
EPA recommends that the oral SF should not be adjusted to estimate the absorbed dose for compounds when the absorption efficiency is greater than 50%.
The GIABS for cadmium (water) and manganese (non-diet)are used for risk calculations.
Since chromium total does not have toxicity values identified in the source, those of hexavalent (VI) chromium are input as surrogates.

Abbreviations:
GIABS – Gastrointestinal absorption factor
INORG – Inorganic
NA – Not available
NJDEP – NJ Department of Environmental Protection
PEST – Pesticide
RSLs – EPA Regional Screening Levels
SFd – Dermal slope factor
SFo – Oral cancer slope factor
SVOC – Semi-volatile organic compound
VOC – Volatile organic compound

Weight of Evidence (Pre-2005 Cancer Guidelines) Definitions:
A Known Human Carcinogen – Sufficient evidence of carcinogenicity in humans
B1 Probable Human Carcinogen – Limited evidence of carcinogenicity in humans
B2 Probable Human Carcinogen – Sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans
C Possible Human Carcinogen – Limited evidence of carcinogenicity in animals and inadequate or lack of evidence in humans

References:

EPA. 2004. Risk Assessment Guidance for Superfund (RAGS) Volume I: Human Health Evaluation Manual. Part E Supplemental Guidance for Dermal Risk Assessment. Final. USEPA/540/R/99/005. July. Available online: http://www2.epa.gov/risk/risk-assessment-guidance-superfund-rags-part-e
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TABLE 6.2
CANCER TOXICITY DATA -- INHALATION
COMBE FILL SOUTH LANDFILL SITE OPERABLE UNIT 2
CHESTER AND WASHINGTON TOWNSHIPS, NJ

Constituent Group	Constituent	CASRN	Mutagenic	Inhalation Unit Risk (IUR)		Weight of Evidence / Cancer Guidelines Description	Source	Source Date
				Value	Units			
VOC	1,2-dichloroethane	107-06-2	N	0.000026	(ug/m3)-1	B2	EPA IRIS	1/1/1991
VOC	1,2-dichloropropane	78-87-5	N	0.00001	(ug/m3)-1	B2 / Likely to be carcinogenic to humans	Cal EPA	2/1/1999
VOC	1,4-dichlorobenzene	106-46-7	N	0.000011	(ug/m3)-1	B2	Cal EPA	2/1/1997
VOC	1,4-dioxane	123-91-1	N	0.000005	(ug/m3)-1	Likely to be carcinogenic to humans	EPA IRIS	11/18/2011
VOC	Benzene	71-43-2	N	0.0000078	(ug/m3)-1	A / Known human carcinogen	EPA IRIS	1/19/2000
VOC	Chloroform	67-66-3	N	0.000023	(ug/m3)-1	B2 / Likely to be carcinogenic to humans	EPA IRIS	10/19/2001
VOC	Cis-1,2-dichloroethylene	156-59-2	N	NA	NA	NA	NA	NA
VOC	Diethyl Ether (Ethyl Ether)	60-29-7	N	NA	NA	NA	NA	NA
VOC	Tetrachloroethylene (PCE)	127-18-4	N	0.00000026	(ug/m3)-1	Likely to be carcinogenic in humans	EPA IRIS	2/10/2012
VOC	Trichloroethylene (TCE)	79-01-6	Y	0.0000041	(ug/m3)-1	Carcinogenic to humans	EPA IRIS	9/28/2011
SVOC	Bis(2-ethylhexyl) Phthalate	117-81-7	N	0.0000024	(ug/m3)-1	B2	Cal EPA	12/1/1997
SVOC	Caprolactam	105-60-2	N	NA	NA	NA	NA	NA
PEST	BHC alpha	319-84-6	N	0.0018	(ug/m3)-1	B2	EPA IRIS	7/1/1993
PEST	Chlordane, alpha	5103-71-9	N	0.0001	(ug/m3)-1	B2	EPA IRIS	2/7/1998
PEST	Endrin Aldehyde	7421-93-4	N	NA	NA	NA	NA	NA
INORG	Aluminum	7429-90-5	N	NA	NA	NA	NA	NA
INORG	Arsenic	7440-38-2	N	0.0043	(ug/m3)-1	A	EPA IRIS	4/10/1998
INORG	Barium	7440-39-3	N	NA	NA	NA	NA	NA
INORG	Beryllium	7440-41-7	N	0.0024	(ug/m3)-1	B1 / Probable human carcinogen	EPA IRIS	4/3/1988
INORG	Chromium, Total	7440-47-3	Y	0.084	(ug/m3)-1	A / Known human carcinogen	EPA IRIS	9/3/1998
INORG	Cobalt	7440-48-4	N	0.009	(ug/m3)-1	Likely to be carcinogenic to humans	EPA PPRTV	8/25/2008
INORG	Copper	7440-50-8	N	NA	NA	NA	NA	NA
INORG	Iron	7439-89-6	N	NA	NA	NA	NA	NA
INORG	Lead	7439-92-1	N	NA	NA	NA	NA	NA
INORG	Manganese	7439-96-5	N	NA	NA	NA	NA	NA
INORG	Nickel	7440-02-0	N	0.00026	(ug/m3)-1	A	Cal EPA	1/1/2011
INORG	Sodium	7440-23-5	N	NA	NA	NA	NA	NA
INORG	Vanadium	7440-62-2	N	NA	NA	NA	NA	NA
Geochemical	Chloride (as Cl)	16887-00-6	N	NA	NA	NA	NA	NA

Note:
The IURs are taken from the June 2015 EPA Regional Screening Levels (RSLs) table, which gathers toxicity reference values from multiple sources using an established hierarchy.
Since chromium total does not have toxicity values identified in the source, those of hexavalent (VI) chromium are input as surrogates.

Abbreviation:
INORG -- Inorganic
IUR -- Inhalation unit risk
NA -- Not available
PEST -- Pesticide
RSLs -- EPA Regional Screening Levels
SVOC -- Semi-volatile organic compound
VOC -- Volatile organic compound

Weight of Evidence (Pre-2005 Cancer Guidelines) Definitions:
A Known Human Carcinogen – Sufficient evidence of carcinogenicity in humans
B1 Probable Human Carcinogen – Limited evidence of carcinogenicity in humans
B2 Probable Human Carcinogen – Sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans
C Possible Human Carcinogen – Limited evidence of carcinogenicity in animals and inadequate or lack of evidence in humans

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EPA. 2015. Integrated Risk Information System (IRIS). February 27. Available online: http://www.epa.gov/iris/